

A CONSCIOUS MOMENT
The unexpected calmness of perceiving

NewScientist

WEEKLY April 11 - 17, 2015

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THE PRINCIPLE THAT RIDES THE WORLD OF WEIRDNESS

THE RIGHT TROUSERS

Put them on and get taken for a walk

FUTURE CRIME

How Moore's law also creates Moore's outlaws

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Brave new world beckons

We must prepare for a genetic revolution in the neonatal unit

SOME time in the next few days a new era in healthcare will be born. Doctors in Boston will sequence the whole genome of a newborn, the first of 240 babies to be fully sequenced. Afterwards, the infants will be monitored for at least five years (see page 8)

The experiment anticipates a time in the near future when whole genome sequencing is a standard part of neonatal care. The potential benefits are huge: parents and doctors will be forewarned about a range of genetic diseases over and above the 30 or so that are picked up by today's screens. Sequencing could save lives and cut healthcare costs. But the wider implications are unknown; hence the experiment.

Neonatal sequencing certainly raises some difficult questions. Although the Boston trial will only look for serious childhood illnesses, neonatal sequencing can also uncover information about more uncertain and long-term risks, such as genes that increase susceptibility for diseases that won't appear until later in life, if at all.

What are parents expected to do with such information? Routine neonatal sequencing risks overwhelming them – and their doctors – with information that is both hard to interpret

and difficult to act upon.

There are other issues too. The Boston team are motivated, in part, by the fact that private companies are champing at the bit to begin commercial newborn sequencing. It is easy to see how this could become a lucrative business. Companies already make a living out of banking umbilical cord blood from newborns as a source of stem cells that may prove useful if the child

“Neonatal sequencing risks overwhelming parents with information that is hard to interpret or act on”

develops a blood disease or immune disorder later in life. According to the American Academy of Pediatrics, the possibility of actually needing the blood is about 1 in 200,000, but that does not stop many parents from banking some, just in case.

You might argue that selling newborn sequencing is little different from existing personalised DNA services offered by companies such as 23andMe. But there is a clear distinction: newborns cannot give informed consent. Parents are rightly empowered to make medical decisions for their children, but sequencing is not like agreeing to

a course of treatment. The child will eventually become an adult who may not want to know their genetic destiny.

The complexities will only deepen as it becomes easier to sequence the genomes of children before they are born. This has already been proved possible in early pregnancy simply by taking a blood sample from the mother. Once it becomes routine, the choices could be agonising: the discovery of a genetic flaw may prompt parents to abort fetuses that would otherwise live largely healthy and productive lives.

And sequencing is just the start of a genetic revolution in prenatal and neonatal care. Advances in biotechnology also raise the possibility of fixing faulty genes in human embryos. Reports have emerged that groups in the US and China are already experimenting with this, prompting calls for a moratorium on such research.

That is an overreaction. Like sequencing, gene editing has enormous potential to alleviate human suffering, and looks unstoppable. But we owe it to ourselves and future generations to proceed with caution. The Boston trial is a vital first step on the road to what could truly be a brave new world. ■



Hoping for an end to sanctions

Breakout deal on Iran

THOSE talks until dawn paid off. Eight days of negotiations in Lausanne, Switzerland – following 18 months of bargaining – have led to an agreement to limit Iran's ability to make a nuclear weapon, subject to verification by the International Atomic Energy Agency.

The deal sets out broad limits on Iran's nuclear activities, in return for the lifting of international economic sanctions. The negotiators will now hammer out the details in time for the final deadline at the end of June.

Iran has promised to cut the 19,000 operating centrifuges at its two declared uranium enrichment plants to 6000. One of the plants will be converted to a nuclear physics research centre, with no fissile material at the site.

The agreement focuses mainly on

“breakout” – the time Iran would need to make a weapon using its declared facilities. Currently, it could enrich enough uranium for one bomb in two to three months. US officials want to stretch that to a year, enough time to launch a military response before a bomb is made. That could be achieved through limits on stockpiles, uranium mining and the number, arrangement and sophistication of centrifuges.

But the real threat is not breakout but breakdown, warns Joe Cirincione, head of the US pressure group Ploughshares Fund. If talks fail over details, he says, countries may desert the process, sanctions will wither, and Iran will resume unconstrained nuclear development, with breakout time dropping to just three weeks.

Climate consensus?

IS THE climate finally right for a new deal on emissions? Several major economies have pledged to cut greenhouse-gas emissions, meeting the UN's April deadline, with a view to signing a deal at a

“A bottom-up approach is more likely to succeed. I am more optimistic than I have been in a long time”

summit in Paris in December.

Top of the range is a 40 per cent cut from the European Union, relative to 1990 levels. The US has reiterated president Barack Obama's commitment to a 26 to 28 per cent emissions cut by 2025, relative to 2005 figures, which Bill Hare of Climate Analytics, a think tank in Berlin, Germany, says will entail doubling the US reduction rate to around 2.5 per cent a year.

The EU pledges trump this, but allow wiggle room to use carbon captured by forest growth and land-use changes as a route to compliance. That could weaken the pledge on industrial emissions “by a few percentage points”, says

Hare. Meanwhile, Mexico has pledged to cut emissions to 22 per cent below “business as usual” levels by 2030.

What sort of a deal this brings remains to be seen. The EU wants a legally binding agreement like the 1997 Kyoto Protocol; the US, China and others prefer voluntary commitments. David Victor of the University of California, San Diego, says the “bottom-up” approach of countries making voluntary commitments for international endorsement is more likely to succeed. “I am more optimistic than I've been in a very long time.”

Abortion law

ARIZONA has passed a law that requires doctors who provide drug-based abortions to tell women that it is possible to reverse the process. But the scientific evidence for this claim is shaky.

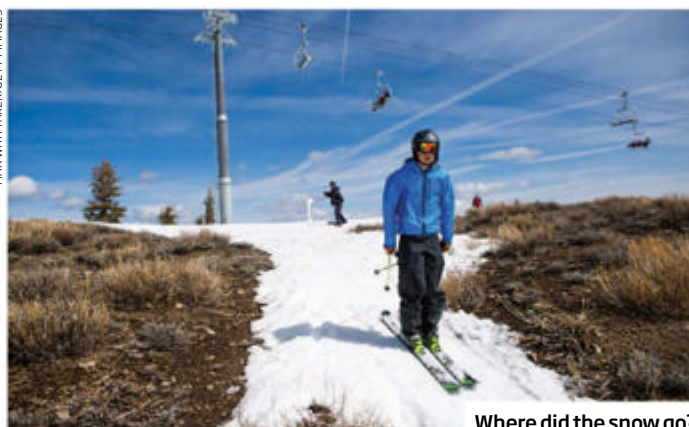
A drug-induced abortion is an option during the first nine weeks of pregnancy and involves taking two drugs 48 hours apart. It can be interrupted before the second dose is taken. George Delgado of Culture of Life Family Services in San Diego says that an injection of progesterone, the hormone that

normally helps maintain pregnancy, at this time can help undo the effects of the first drug.

But the strategy is controversial. “There's no proof that progesterone works,” says Patricia Lohr of the British Pregnancy Advisory Service. “The only way to tell if it's effective is by doing a randomised trial.”

“This is another example of anti-abortion pseudoscience, which unfortunately is becoming common practice in the US,” says Marge Berer of the International Campaign for Women's Rights to Safe Abortion.

MAX WHITTAKER/CETTY IMAGES



Where did the snow go?

California drought

WELCOME to the new, drier California. When the snowpack is measured at Phillips in the state's Sierra Nevada mountains on 1 April each year it typically comes to 1.5 metres of snow. This year, for the first time, there was none.

State governor Jerry Brown stood at the snowless spot last week and declared a mandatory 25 per cent cut in water use across the state. “We are in a new era,” he said.

California's snowpacks are its natural reservoirs. This January was the state's driest since records began, says Jay Famiglietti of NASA's Jet Propulsion Laboratory in California. High temperatures mean the precipitation there falls as rain not snow, which flows off the mountains rather than becoming stored in the snowpack.

Climatologists predict that persistent megadroughts will be a feature of climate change in the American West. And California, with the West's largest population and the country's biggest agricultural output from irrigated fields, could suffer the most.

Brain race

WHAT'S going on in your head? No one really knows how the brain works... yet (see page 10). But billions of dollars are being poured into giant projects around the world to figure it out.

Huge brain projects have been launched in the US, Europe, China, Israel, Japan and Canada. Japan's Brain/MINDS project – focused on understanding the non-human primate brain – is set to receive around \$30 million a year over the next decade. Between 2013 and 2023, the European Brain Project is expected to cost a cool \$1.3 billion. The US project, called the BRAIN initiative, was launched in 2013 with funds of \$100 million – a figure that the team says is being ramped up to \$400 million annually over the next five years, after which it should be increased to \$500 million a year until 2025.

The teams don't admit to competing in a global brain race, though. "Most of us see competition as good," John Donoghue, a member of the US National Institutes of Health committee on the BRAIN initiative, told the Brain Forum meeting in Lausanne, Switzerland, last week. "The hope is that this will lead to a global initiative, like the International Space Station."

Cyber sanctions

CYBERCROOKS beware: Obama is coming for you. The US president declared a national state of emergency over cybercrime at the start of April, promising to use the "authorities of my office" to track down and punish malicious hackers that threaten the country. Unfortunately, it seems the plan may be doomed to fail.

The order is meant to give the government power to punish people or organisations who attack US infrastructure over the internet. But there's a glaring problem with the plan: unless the

individuals or entities Obama plans to catch are incompetent, it will be practically impossible to pin an online attack on them, says cybersecurity analyst Jeffrey Carr. Forensic scientists can trace the computers that incoming malicious connections came from, but they will still have no idea who controlled the computer. Any clever attacker will hide their tracks, and it would take an exceptionally stupid one to launch an attack from a computer in their own basement, he says.

"Going after the attackers is a failed policy," says Carr. "You have to strengthen your defences."

LHC powers up after upgrade

THE beam is back. Last Sunday morning, a pulse of protons flew around the Large Hadron Collider near Geneva, Switzerland, for the first time in two years.

This is the first milestone in the rejuvenation of the world's largest particle collider. Upgraded magnets and electronics will enable it to smash protons together with 13 teraelectronvolts (TeV) of energy, double that of the old LHC.

Physicists hope that the revamped collider will help find new physics beyond the standard model – the existing theory of particles and forces. The Higgs boson, discovered at the LHC in 2012, was the missing piece of this model, but the theory does not include a host of things that

physicists know exist, such as dark matter and gravity.

But first, the LHC needed to warm up. Sunday's beams circulated at a test energy of 0.45 TeV, about 7 per cent of the energy each beam would need to reach 13 TeV in a collision. CERN's head of beams, Paul Collier, says the team expects the first collisions between two bunches of protons to happen in June.

"We have unfinished business with understanding the universe," says Tara Shears of the University of Liverpool, UK, who works on an experiment called LHCb. "We want to chase the hints we've seen in previous measurements, whose behaviour didn't quite match our expectations."

REUTERS/PIERRE ALBOUY



Back in business

60 SECONDS

Face/neck transplant

Life-threatening growths of blood vessels disfiguring a Spanish man's face have been replaced in one of the most complex face transplants yet. A team of 45 at the Vall d'Hebron Hospital in Barcelona took 27 hours to reconstruct two thirds of the man's lower face, neck, mouth, tongue and pharynx.

Thunder lizard's back

Poor old Brontosaurus lost its name when palaeontologists decided it was the same as an Apatosaurus. Except maybe it wasn't. A reanalysis now suggests that Brontosaurus is in fact its own unique genus (*PeerJ*, doi.org/3f7).

Rocky melt

Western Canada's ice is melting faster than expected – and as much as 90 per cent of its inland glaciers may vanish by 2100. That's the prediction from a new way of modelling ice loss, which suggests that the melting of other glaciers may also have been underestimated (*Nature Geoscience*, DOI: 10.1038/ngeo2407).

Height advantage

Is being tall evolutionarily favourable? An analysis of 94,500 Dutch citizens between 1935 and 1967 suggests so, showing that tall men had more children on average than short men, helping the Dutch rise in height by 20 centimetres in 200 years (*Royal Society Proceedings B*, DOI: 10.1098/rspb.2015.0211).

Speedy battery juice

A new aluminium battery can charge in less than a minute. Aluminium batteries are safer in gadgets than traditional lithium-ion batteries but usually don't last as long. This one, created by Hongjie Dai and his team at Stanford University in California, survived for 7500 charge cycles – lithium-ion batteries can usually only manage about 1000 (*Nature*, DOI: 10.1038/nature14340).

Baby's genes mapped at birth

Gene sequencing for babies is coming. What can we do now to make sure it's done right?

Helen Thomson

IF YOU could gaze into a crystal ball and discover whether your newborn baby might have health problems, would you want to know? This month, doctors in Boston will begin sequencing the genomes of healthy babies for the first time to explore the benefits and risks of sequencing at birth.

"We've been at an impasse for the last few years – we've had the technology to deliver information about future health, but we've not been able to use it because of all the issues around it," says Robert Green of Harvard Medical School, who is conducting the BabySeq project alongside Alan Beggs at Boston Children's Hospital.

Pregnant women already have blood tests to assess their risk of passing on certain genetic diseases, such as cystic fibrosis. Those at high risk may choose to have further tests, such as amniocentesis, to determine if their unborn child has

"It's our responsibility to work out what harms may occur before it is launched on an unsuspecting public"

chromosomal abnormalities. But we're on the cusp of knowing so much more.

In 2012, two groups showed that it is possible to sequence a fetus's entire genome using fetal DNA circulating in the mother's blood. While this is still some way from being used in the clinic, whole genome sequencing at birth is not. "Despite the well-recognised limitations in the predictive value

of sequencing, there are many companies out there that feel they could be offering newborn sequencing right now," says Green. "We felt it was our scientific responsibility to begin this kind of sequencing so if harms do occur we are available to mitigate them and have an understanding of them, before it is launched unmonitored on an unsuspecting public."

When babies are born, a spot of blood is routinely taken from their heel and analysed for signs of up to 30 treatable diseases. In the BabySeq project, 240 healthy babies born at the Brigham and Women's hospital in Boston, and 240 babies in intensive care at Boston Children's hospital will have their genome sequenced alongside the heel prick test, or have the heel prick test alone.

The team will carry out whole genome sequencing, looking at 1700 protein-coding genes that are strongly associated with diseases that begin in childhood. This could include Usher syndrome, which causes deafness and gradual vision loss. They will also be looking for mutations linked to diseases that occur in older children or adults that can be mitigated in childhood, such as familial adenomatous polyposis (FAP) in which polyps grow in the colon and eventually turn cancerous. And they will hunt for genes associated with incurable childhood conditions, such as Rett syndrome, where advance warning should mean parents are better prepared. At the moment, a healthy baby would not be screened for any of these

conditions unless there was a family history of the disorder.

The results of the analysis will be summarised and explained to parents by a geneticist and a genetic counsellor. The summary will also be given to the infant's paediatrician and used to guide their medical care. For example, it might mean a child with Usher syndrome is fitted with a cochlear implant earlier or a child with FAP has regular checks for colon polyps, says Caroline Weipert, one of BabySeq's genetic counsellors. The team will monitor the child, parents and their physician for at least five years.

The team will not look for any gene mutations associated with adult diseases such as Alzheimer's or breast cancer in their analysis.

Parents will not have access to

their child's raw data unless they request it – which they can do at the end of the project. "We are uncomfortable about releasing raw data as someone could analyse it inappropriately," says Green. "But if the family insists, they can request it from the lab who may release it after a discussion with the parents."

Might it be possible for a parent to later discover other traits about their child? "They won't be able to discover much," says Robert Plomin, professor of behavioural genetics at King's College London. "People will be told by companies 'yeah you can predict intelligence and musical ability and sport', but you can't."

The genetic heritability of traits that we know most about are those for height and weight,



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Future health: written in my DNA

he says. "That could come in useful for predicting which of your kids might be prone to obesity so you can keep an eye on their diet or lifestyle."

Plomin says that the rise of genetic sequencing in children is inevitable: "That's what's good about this project – it's going to happen sometime, so let's see what the problems are now in a randomised trial."

It's important to study the impact of genomic screening in a safe and controlled manner, agrees Donna Dickenson, an emeritus professor of medical ethics at the University of London.

"Market forces are driving personalised medicine to a considerable extent," Dickenson also highlights some of the ethical implications: is the medical benefit to the child greater than the harm of removing the child's right to choose? Might styles of parenting be affected?

"We know the questions that the world has about this issue, and we have to start trying to answer them," says Green, "but we're not going to be able to do that by speculating. We answer them by starting a project in a carefully monitored environment, so that if something goes awry or causes unexpected distress, we are in a position to say 'wait, stop, let's not go down this road', and then document the fact that it has happened." ■

"Is the medical benefit to the child greater than the harm of removing their right to choose?"

IS NEWBORN SEQUENCING FOR ME?

AT 31 years old, not a day goes by without overhearing one of my friends discuss the pros and cons of breast versus bottle, one buggy over another. Before long the topic may be to sequence or not to sequence.

From this month, parents in Boston will have the opportunity to take part in the BabySeq trial and have their baby's genetic future analysed and entered into their medical records. In doing so, the child's parents will find out if their infant is at risk of a range of medical conditions, some of which might be preventable.

It sounds like a good idea, an extension of the heel prick test that newborns already receive. But sequencing has the potential to reveal much more as time goes on and our knowledge of the genome increases – both about medical conditions and other traits.

"People will propose a number of disturbing scenarios," says co-leader of the trial, Robert Green at Harvard Medical School. "For example, could a parent discover something that makes them treat the child differently, or could a child grow up and face discrimination because of having certain gene mutations in their medical records?"

As a woman of child-bearing age, I'm certainly interested in technology that might help prevent any future child suffering with a preventable condition. The problem with genetic screening is that the

results are never black and white.

Take Mary (not her real name), for example. She took part in MedSeq, an adult version of BabySeq that has been running for over a year. Of 100 healthy people who had their genome sequenced as part of the trial, Mary was one of a few who discovered a mutation associated with a life-threatening condition. She had a gene variant associated with long QT syndrome, which causes abnormal heart activity.

SELF-FULFILLING PROPHECY

Having survived into her 50s with no major health problems, she was told she was at risk of sudden cardiac death and shouldn't take certain medications. Could the stress of that knowledge make the diagnosis a self-fulfilling prophecy? What if she had known about it from birth – how different would her life have been? How do I prepare myself for finding out that kind of information about my future child?

And who's to say my child's genome won't end up in the wrong hands? Green says the MedSeq data will be kept under digital lock and key, but admits that there is no way to promise complete protection from foul play. Personally, I have faith in reactive laws that adapt to the changing landscape of personalised medicine – but I know people who think they aren't worth the paper they're written on. So how will my child feel?

Perhaps I should shy away from the whole thing, and be happy in my ignorance of their genetic future. But what if in 18 years' time, my teenager is now in the minority, part of a generation who had access to their genome from birth and used it to get ahead in life? "I think by the time the kid is 18, sequencing will be so common that healthcare without genomics would be almost unimaginable," says Green.

He could be right. When the price is right, people will inevitably demand this kind of genetic insight into their children's future. The BabySeq trial will give us a feel for the landscape ahead. Now that sounds like a good idea. Helen Thomson ■



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Testing times



A stable mind is a conscious mind

Anil Ananthaswamy

HOLD that thought. When it comes to consciousness, the brain may be doing just that. It now seems that conscious perception requires brain activity to hold steady for hundreds of milliseconds. This signature in the pattern of brainwaves can be used to distinguish between levels of impaired consciousness in people with brain injury.

The new study by Aaron Schurger at the Swiss Federal Institute of Technology in Lausanne doesn't explain the so-called "hard problem of consciousness" – how roughly a kilogram of nerve cells is responsible for the miasma of sensations, thoughts and emotions that make up our mental experience. However, it does chip away at it, and support the idea that it may one day be explained in terms of how the brain processes information.

Neuroscientists think that consciousness requires neurons to fire in such a way that they produce a stable pattern of brain activity. The exact pattern will depend on what the sensory information is, but once information has been processed, the idea is that the brain should hold a pattern steady for a short period of time – almost as if it needs a moment to read out the information.

In 2009, Schurger tested this theory by scanning 12 people's brains with fMRI machines. The volunteers were shown two images simultaneously, one for each eye. One eye saw a red-on-green line drawing and the other eye saw green-on-red. This confusion caused the volunteers to sometimes consciously perceive the drawing and sometimes not.

When people reported seeing the drawing, the scans, on average, showed their brain

Material brain, ethereal experience

activity was stable. When they said they didn't see anything, it was more variable. Now, Schurger and colleagues have repeated the experiment – using electroencephalography and magnetoencephalography, which measure the electrical and magnetic fields generated by brain activity. These techniques provide greater temporal resolution than fMRI, allowing the team to see how the pattern of activity changes over milliseconds within a single brain.

Based on their earlier work, the team expected the volunteers' brain activity to stabilise and stay

"How do brain processes lead to consciousness? This study pins down the speculation with data"

that way for hundreds of milliseconds when they reported having seen the drawing, but become highly variable otherwise. "This was borne out really, really nicely in the data," says Schurger.

The team then tested their technique in 116 people with disorders of consciousness. The patients, who were either minimally conscious, in a

vegetative state or had just recovered from coma, were played a tone while their brain activity was recorded. The ability of their brains to converge on a stable state correlated with their clinical diagnosis: the more conscious the patient, the greater the stability. "The stability of their brain's response to an auditory beep is an indicator of their state of consciousness," says Schurger.

Neurologist Steven Laureys of the University of Liège in Belgium thinks the work is significant. "The challenge is to translate this into real clinical practice, by cross-validating this new test with other measures. This is terribly important in a field where we have no gold standard of consciousness," he says.

The work augments the global neuronal workspace theory of consciousness – which argues that a number of brain regions erupt in synchronous activity when people report being conscious of something. The findings support the idea that this synchronous activity should remain stable for a few hundred milliseconds.

Michael Graziano of Princeton University is also impressed. "Somehow, processes in the brain lead us to report that we have conscious experiences. What are those processes? How do they occur? This study is a beautiful example of pinning down the speculation with data," he says.

However, it doesn't directly address the hard problem of consciousness. Many neuroscientists, including Graziano, think that the hard problem is an illusion, one that will go away as we better understand the brain. "There is no hard problem," says Graziano. "There is only the question of how the brain, an information-processing device, concludes and insists it has consciousness. And that is a problem of information processing. To understand that process fully will require the kinds of stepwise experiments you see here." ■

Why nothing could shed light on dark energy

HOLES in the universe could help explain why it's ripping apart. The number and size of cosmic voids could shed light on the mysterious dark energy that is causing the universe to grow at an ever-increasing pace.

In the late 1990s, astronomers realised that the expansion of the universe was accelerating and attributed this to the inherent "dark energy" of space-time.

But we understand little about dark energy. Each unit of space-time contains some, but if this energy density changes with time, it implies different fates for our universe. If it is constant, as current observations suggest, then the universe will expand forever. But if it changes, we could be heading for a more dramatic end, like a big rip or a big crunch.

One way to understand whether dark energy changes with time is to observe its effect on the large-scale structure of the universe. Just instants after the big bang, quantum fluctuations in the fabric of space-time led to regions that had more matter than their neighbours. As the universe expanded, the denser regions evolved to form clusters of galaxies. The less dense regions became voids – regions of space-time almost empty of matter, which can stretch from 30 million to 150 million light years across.

While most efforts at deciphering dark energy involve studying its effect on clusters of galaxies, Alice Pisani and colleagues at the Paris Institute of Astrophysics decided to see if dark energy influenced the number of

voids in the universe. "Voids are just an unavoidable part of the distribution of matter in the universe," says team member Benjamin Wandelt.

It turns out that there was a time in the evolution of the universe when the effects of dark energy kicked in and stopped the formation of new large-scale structures, whether clusters or voids. The properties of dark energy influenced when this happened and therefore the

"Voids are just an unavoidable part of the distribution of matter in the universe"

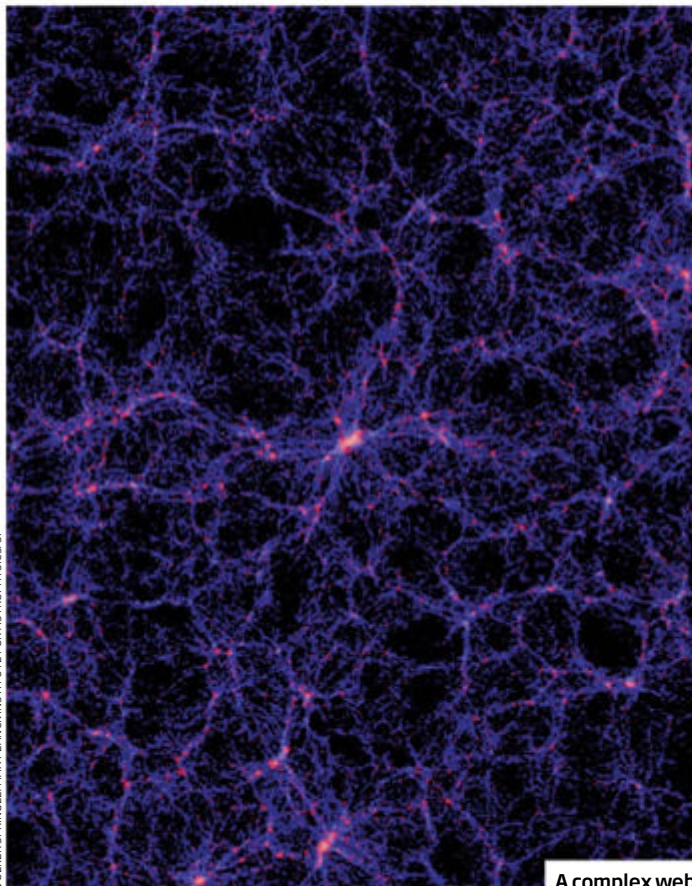
distribution of these structures.

Pisani and colleagues considered three scenarios, all of which can explain the observed rate of expansion today. One was that dark energy is a cosmological constant; in the other scenarios, dark energy changed with time. The second

caused the expansion to accelerate later but faster than the cosmological constant would have, and in the third, it was earlier but slower.

"Depending exactly on when the universe started accelerating, you have more or less voids of various sizes," says Wandelt. The team's analysis shows that with later but faster acceleration, there should be more big voids but fewer smaller ones compared with the cosmological constant. The opposite would be the case for acceleration that began earlier but was slower (arxiv.org/abs/1503.07690).

Observations are not yet good enough to differentiate between the three scenarios but the European Space Agency's Euclid mission, due for launch in 2020, will study more voids than ever before. The Paris team says its analysis could be applied to the Euclid data to elucidate dark energy, alongside studies investigating clusters. Anil Ananthaswamy ■



A complex web

Continental loss: the quest to determine Antarctica's contribution to sea-level change

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Did neurons evolve twice on Earth?

Catherine Brahic

TRANSLUCENT comb jellies are some of the most primitive animals on Earth, yet they have remarkable nervous systems. Controversial data discussed at a meeting in London last month proposes that their neurons are unlike any others on Earth. This could be evidence that neurons evolved more than once in the history of animal life.

The suggestion that neurons evolved in parallel multiple times has divided biologists for over a century. Ultimately, Erich Jarvis of Duke University in North Carolina told a Royal Society

conference in March, the question relates to how special we are. If neurons evolved several times on our planet, then it becomes more likely that they could evolve elsewhere in the universe.

Until recently, the consensus has leaned towards a very Darwinian story. In this scenario, sometime around 600 million years ago, the common ancestor to all animals gave rise to some organisms with simple neural networks. Central nervous systems arose later, allowing for greater coordination and more complex behaviours. These perhaps started out as tight balls of neurons, but eventually



JEFF WILDERMUTH/NGS

A different way of thinking

gave rise to the magnificently complex primate brain.

This single origin scenario offers a tidy explanation for why some animals, like sponges and flat, simple placozoans, still don't have neurons: they must have branched off before these evolved

and are relics of ancestral animals (see diagram, right).

The story was somewhat turned on its head by the recent whole genome sequence of comb jellies. These small marine animals look like jellyfish but in fact seem to be only distantly related. They use a

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neural network just beneath their skin and a brain-like knot of neurons at one end to catch food, respond to light, sense gravity and escape predators.

When the first full genome of the comb jellyfish was published in December 2013, it suggested they had branched off from the animal family tree earlier than jellyfish, and before the brainless sponges. If comb jellies came first

signalling molecules in comb jelly neurons and found that they are completely different to the ones used in all other neurons (*Nature*, doi.org/3cf). It's as if alien nerves were found right here on Earth, says Moroz. "If aliens landed on our planet, you would expect the chemical makeup of their brains to be different to any other nervous system."

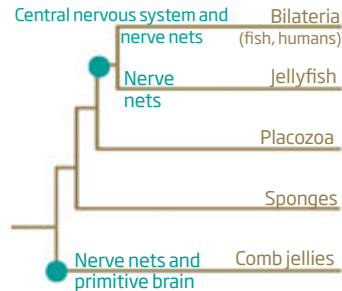
But biologists are divided. Gáspár Jékely of the Max Planck Institute for Developmental Biology in Tübingen, Germany, and others still favour brainless sponges as the most primitive animals, maintaining that the genomic studies placing comb jellies as older are flawed.

Pedro Martínez of the University of Barcelona in Spain points out that brains can acquire a different chemistry by going through periods of accelerated evolution, as has happened in

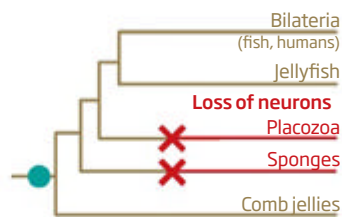
Neuronal evolution

Two possible scenarios explain how animals evolved neurons

Multiple origins of neurons...



...or single origin of neurons



flatworms. So it's possible that the nervous systems of comb jellies and bilaterian animals like fish and humans do share a common origin, they have just become very different from each other.

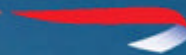
The controversy is repeated for the evolution of complex, centralised brains. There's no clear single point in the evolutionary tree of animals where complex brains appear – according to Moroz, central nervous systems evolved independently no less than five times in molluscs alone.

Martínez agrees that brains probably evolved several times from simple neural networks. "If you look at individual groups of animals, you see that at the base of each group are animals with a neural network," he says. "This to me points to the possibility that these nervous systems most probably appeared independently." ■

"If aliens landed on Earth, you would expect the chemical make up of their brains to be different"

and sponges came later, says Leonid Moroz of the University of Florida at Gainesville, then either sponges lost their neurons or neurons were invented twice.

Moroz favours the second explanation. He and his team have taken a close look at the



BRITISH AIRWAYS

INSIGHT Illegal wildlife trade

Consumers starting to reject ivory

Penny Sarchet

AFTER decades of trying to crack down on illegal poaching, governments and conservation groups are now turning their attention to the huge demand for wildlife products that drives the crime in the first place.

At a conference in Botswana last month, delegations from 32 countries called for a better understanding of the market forces that drive the illegal wildlife trade. It's a big improvement on a similar declaration issued last year, which failed to discuss how to reduce demand for products like rhino horn.

"People have not been focusing on demand at all," says Grace Ge Gabriel, Asia director for the International Fund for Animal Welfare (IFAW). "We can put all our money into anti-poaching, but if we don't change behaviour in the marketplace, we're not going to make an impact."

So conservation groups have been looking east. "China is clearly the biggest player in terms of exploitation of wild animals," says Adam Roberts of Born Free USA. "China is the biggest consumer of elephant ivory in the world."

China also drives the illegal trade in tiger parts, rhino horn, shark fins and pangolins. But the demand for wildlife parts is increasingly coming from the luxury goods market, rather than traditional medicine.

"Fundamentally it's about luxury items and greed," says Roberts. For

example, where bear bile and gall bladders were once used for medicine, they are now added to luxury cosmetics. "Traditional medicine practitioners are becoming less important in the consumption of wildlife parts, and it's transferring more to the big businessmen," he says.

It's a trend that has been fuelled by China's huge consumer power. But the fact that ignorance seems to underlie this demand offers hope. An IFAW survey in China found that 70 per cent of respondents didn't know that ivory can only come from dead elephants.

"We also found that 83 per cent of those people who had bought ivory said that they wouldn't have purchased it if they had known," says Gabriel.

It's early days, but public awareness campaigns launched across China may already be having an effect. According to Roberts, the demand for ivory seems to be falling. Each year the Chinese government releases a portion of its stockpile of ivory for legal use, but only 80 per cent of the most recent allocation has been taken up.

It's not just ivory sales that are being targeted. Another campaign has tackled shark fin soup. Early efforts like these may be having some effect: recent research shows that shark capture is now declining. Many students have persuaded restaurants to stop serving shark fins.

Will such efforts be enough to save critically endangered species? "If there is no demand for these products then the markets are going to dry up, and if the markets dry up, there's no need to poach," says Roberts.

But species like rhinos are running out of time, and it could take a generation or two to bring down the financial incentives for poaching. In the meantime, more traditional enforcement approaches, particularly in Africa, will remain vital, alongside these new campaigning approaches. "From an economic perspective, it's a very interesting and poignant time in wildlife conservation," says Roberts. ■



Item of desire?

Fossil forests feed life under Antarctic ice

WHITE on top, but what lies beneath? Antarctica's blanket of snow and ice sits atop a vast and rich landscape of volcanoes, rivers and lakes. Results from the first expedition to sample the sediment beneath the ice are revealing how the remnants of ancient forests are fuelling the communities that live there today.

Lake Whillans sits beneath nearly

1 kilometre of ice in West Antarctica. Despite its heavy frozen lid, it is full of liquid water.

In January 2013, a US team drilled through the ice and sampled the lake's water and the sediment beneath.

The sediment contained microfossils of marine organisms and fossilised pollen from beech trees and conifers. Slawek Tulaczyk of the University of California at Santa Cruz told a meeting on subglacial Antarctic lakes held at Chicheley Hall near London last week.

The pollen dates back to before 34 million years ago, at a time when

Antarctica was a collection of lush forested islands separated by salty fjords. Both are providing much-needed nutrients to a completely different community that now occupies the area; the water samples from the lake revealed a thriving microbial community that was living in the pitch dark and at huge pressures and low temperatures.

"I like to think that the long-dead

"I like to think long-dead life from a happier time is feeding the modern microbial ecosystem"

life from a much happier time is now feeding the modern microbial ecosystem," says Tulaczyk.

The team have found bigger things too. In January they drilled down to a nearby subglacial beach and were stunned to find fish and crustaceans living in the dark.

Ross Powell of Northern Illinois University says they have evidence the fish are stressed and struggling to survive, most likely because they are starved of nutrients. They may have fled from an even worse environment, or could be early pioneers of a new subglacial world. Catherine Brahic ■

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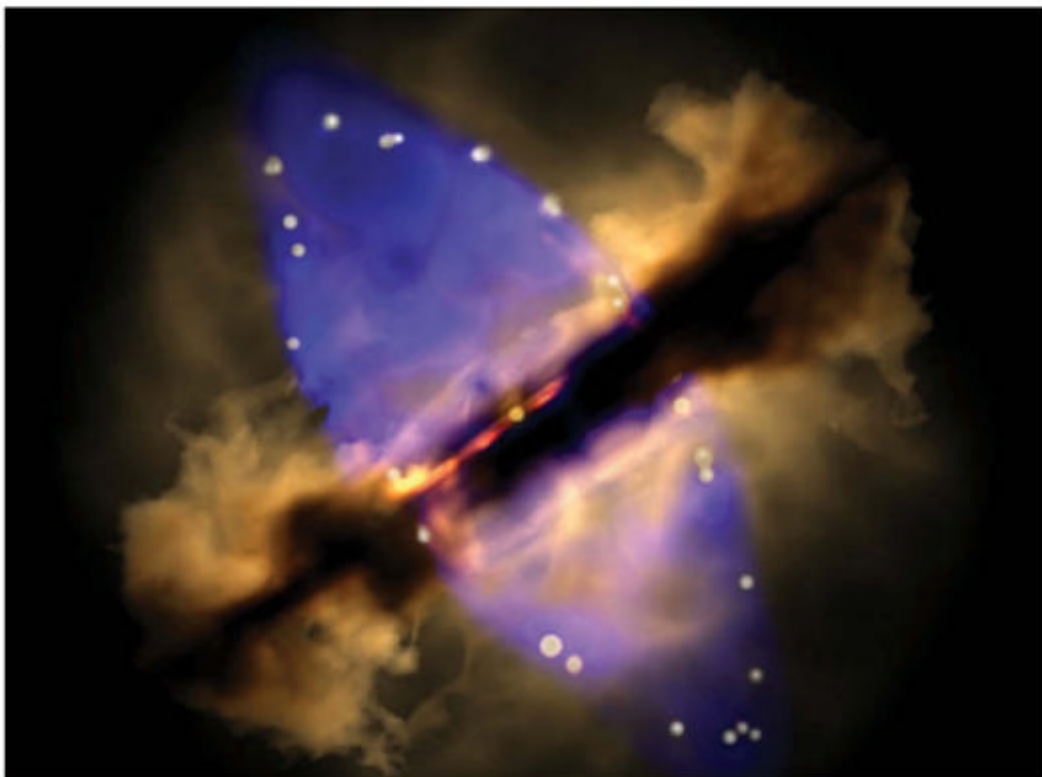
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Before-and-after shots show how stars get massive

THE violent birth of massive stars has been captured for the first time in dramatic before-and-after images, which are already overturning theories about how these planet-factories form.

Massive stars – those at least eight times the mass of our sun – are relatively rare in the universe. They act as factories that create the heavier elements required for the formation of planets and life. But how they grow so massive is a mystery, as they emit so much radiation that it pushes away incoming material.

One possibility is that the radiation comes from the

poles of the forming star, allowing material to fall in around its equator. But all the models showing this depend on the outflow being focused from the very beginning of the star's formation, says Carlos Carrasco-González of the National Autonomous University of Mexico.

Now, in a pair of radio images taken 18 years apart with the Jansky Very Large Array in New Mexico, Carrasco-González and colleagues have revealed a massive star switching from a state with no focused outflow to one where the outflow clearly shoots out from the poles (*Science*, DOI: 10.1126/science.aaa7216).

Inspired by this observation, the team developed a model that suggests the matter surrounding the star has a doughnut shape, which squeezes the outflowing radiation and forces it to focus along one axis.

Flame-proof fabric fights water too

NOW you can safely wash your flame-proof suit. A coating can make cotton fabric both flame retardant and water repellent.

Fabrics with flame-retardant coatings are fire-fighter chic, but they are also used for curtains and furniture. The problem is these coatings are water soluble, so can be worn away by washing.

Now Junqi Sun of Jilin University in China and his

colleagues say they have the answer. Water-repellent coatings already exist – why not combine the two into a single material?

The team took ordinary cotton and soaked it in a solution of a polymer called polyethylenimine, which acts as a binding agent, then in a solution of ammonium polyphosphate, a common flame retardant. Finally, they dipped the fabric in a mix of ethanol and a

silsequioxane, a cage-like molecule that has shown promise as a water repeller.

The result was a fabric that refuses to catch fire and is easily cleaned. The team placed a strip of uncoated cotton over a flame and it burned up completely in just 14 seconds. When they did the same with the coated fabric, it charred slightly and was extinguished as soon as the flame was removed (*ACS Nano*, doi.org/297).

Werewolf plant waits for full moon

IS THE moon at its fullest? This shrub will know – it's the first plant ever discovered to sync its activity to the lunar cycle.

A relative of conifers and cycads, *Ephedra foeminea* oozes tiny beads of sugary liquid to attract nocturnal pollinating insects. But Catarina Rydin and Kristina Bolinder of Stockholm University in Sweden found that the plant only springs into action when the moon is full.

"At night, the many pollination drops glitter like diamonds in the full moonlight, a spectacular sight also for the human eye," Rydin and Bolinder report (*Biology Letters*, DOI: 10.1098/rsbl.2014.0993).

They made this discovery by accident, returning to visit plants in Croatia and Greece every year, but failing to witness any pollination during their 2013 trip. "All of a sudden, there was a eureka moment," says Rydin.

Hot rivals compel men to take risks

THERE's nothing like the sight of a rival to embolden a man, it seems.

When straight men see another man they perceive as more attractive than themselves, they try to quickly increase their wealth by making high-risk decisions, says Eugene Chan from the University of Technology in Sydney, Australia. His team showed images of male models to heterosexual male volunteers and got them to play lab-based betting games. Making the group imagine wooing a woman also made them bolder (*Evolution and Human Behaviour*, doi.org/3bz).

"This financial risk-taking occurs because men want to appear more desirable to women, and having more money is one way to do so," says Chan.

Bagpiper fish warns intruders

IT'S pretty musical, for a fish. Male Lusitanian toadfish make at least five kinds of call, including a long, rhythmical sound called a boatwhistle that attracts mates.

Now it seems the boatwhistle also has another function: males use it as a keep-out signal to rivals, in order to protect the nests they build during the mating season.

To study the toadfish's use of boatwhistles, Clara Amorim at ISPA University Institute in Lisbon, Portugal, and her team deflated the swim bladders of some toadfish. This organ normally works like a bagpipe, making different sounds depending on how it is squeezed by surrounding muscles. Deflating this organ left the fish unable to sing.

They found that the nests of these muted males were more likely to be invaded (*Journal of Experimental Biology*, doi.org/3b3).

Some aspects of toadfish boatwhistles, such as frequency and pulse interval, are associated with the size of the fish, meaning that others can use the sound to assess the quality of potential mates or the fighting ability of rivals.

"Boatwhistles are a cheap way to exclude intruders without engaging in a fight," says Amorim. "Seeing that a nest is occupied is not as effective as hearing that there is a male in the nest eager to defend its territory."



Blind rats can navigate with a digital compass in their brains

WHO needs sight when you've got psychic GPS? An implanted digital compass that feeds signals into the brains of blind rats has enabled them to navigate.

The result shows that rats can learn to deploy an unnatural "sense" and raises the possibility that humans could do the same. It could prompt alternative ways to treat blindness, or even equip healthy people with extra senses.

The neuroprosthesis, created by a team at the University of Tokyo in Japan, consists of a geomagnetic compass and two

electrodes that fit into an animal's brain. When the rat positioned its head within 20 degrees either side of north, the electrodes sent pulses to its right visual cortex. When the rat aligned its head in a southerly direction, the left visual cortex was stimulated. This let blind rats build a mental map of their surroundings.

During training, blind rats equipped with the compass improved at finding food rewards in a five-pronged maze, despite being released from one of three arms of the maze at random each

time. After two days and 60 trials, they could navigate to the reward as fast as sighted rats could. Blind rats with no additional senses were much slower to locate the reward and didn't show any improvement (*Current Biology*, DOI: 10.1016/j.cub.2015.02.063).

"In theory, it would be possible to augment human perceptual capabilities using this approach, but many more studies in animals have to be done to justify any human study," says Miguel Nicolelis of Duke University in Durham, North Carolina.

Slap on TAPE to stop bleeding fast

IT DOESN'T come unstuck when things get sticky. An adhesive with remarkable strength could be ideal for patching people up after surgery.

Most glues are not suited to medical applications: they may be toxic, or fail when exposed to moisture. Others, like fibrin, are costly and not particularly sticky.

But a mixture of two cheap, safe chemicals seems to solve these issues, creating an adhesive that sticks to tissues covered in blood or mucus. Bandages coated in it are even reusable, like a Post-it Note.

Haeshin Lee from the Korea Advanced Institute of Science and Technology and colleagues mixed tannic acid – an antibacterial compound found in plants, and that gives wine its edge – with polyethylene glycol or PEG, which can help rejoin broken nerves. He called the resulting substance TAPE (*Advanced Functional Materials*, doi.org/f26jp5).

They tested its ability to stop bleeding by poking a hole in a mouse's liver and sticking it back together. After 30 seconds, TAPE-treated mice had bled one-sixth as much as those treated with fibrin. Within 2 minutes, the TAPE mice had stopped bleeding altogether.



A plague on prairie dogs' houses

PLAGUE is creeping through the grasslands of the US. The same bacterium that caused the Black Death seems to be quietly and irrevocably changing the landscape.

Though the plague bacterium, *Yersinia pestis*, now rarely infects people in North America, it has been responsible for the deaths of many black-tailed prairie dogs. This is a problem for the grasslands, where many other species rely on prairie dogs to survive. Predators eat them, animals make homes in their burrows and grass growth is shaped by them (*Conservation Biology*, doi.org/3cj).

The ecosystem will be affected by their disappearance, says David Eads at Colorado State University in Fort Collins. "The connection between these animals and plants will be distorted and even broken."

To stem the problem, Eads and colleagues are searching for new ways to control the spread of the plague. They are experimenting with an insecticide called Delta Dust to see if that reduces the numbers of fleas. "If we can't control the problem, the grasslands are probably going to be far different within the next 100 years," says Eads.



Human cruise control

Electrodes attached to legs can guide people wherever you want them to go via an app. Welcome to the bizarre world of electro-stimulation

Hal Hodson

FOR a few days last summer, a handful of students walked through a park behind the University of Hannover in Germany. Each walked solo, but followed the same route as the others: made the same turns, walked the same distance. This was odd, because none of them knew where they were going.

Instead, their steps were steered from a phone 10 paces behind them, which sent signals via bluetooth to electrodes attached to their legs. These stimulated the students' muscles, guiding their steps without any conscious effort.

Max Pfeiffer of the University of Hannover was the driver. His project directs electrical current into the students' sartorius, the longest muscle in the human body, which runs from the inside

of the knee to the top of the outer thigh. When it contracts, it pulls the leg out and away from the body. To steer his test subjects left, Pfeiffer would zap their left sartorius, opening their gait and guiding them in that direction.

Pfeiffer hopes his system will free people's minds up for other things as they navigate the world, allowing them to focus on their

conversation or enjoy their surroundings. Tourists could keep their eyes on the sights while being imperceptibly guided around the city.

Acceptance may be the biggest problem, although it is possible that the rise of wearable computing might help. Pfeiffer says the electrode's current causes a tingling sensation that

diminishes the more someone uses the system. Volunteers said they were comfortable with the system taking control of their leg muscles, but only if they felt they could take control back.

One of the students compared the feeling to cruise control in a car, where the driver can take control back when they want it. "Changes in direction happened subconsciously," said another.

Pfeiffer steered students manually, but the plan is to build

"Tourists could keep their eyes on the sights while being imperceptibly guided around the city"

the mechanism into other apps. Navigation apps, for instance, could steer people along their route automatically, meaning they never have to look at their phone or think about where they are going.

"When I use Google Maps and I navigate somewhere, I am always pulling my mobile out of my pocket to check," he says. "We want to remove this step out of the navigation process so you just say 'I want to go there', and you end up there."

The system could also be used to direct crowds, not just individuals. "Imagine visitors to a large sports stadium or theatre being guided to their place, or being evacuated from the stadium in the most efficient way in the case of an emergency," the team write in a paper that will be presented at the CHI conference in Seoul, South Korea, next week.

Evan Peck of Bucknell University in Pennsylvania says Pfeiffer's system will stop us being chained to our smartphones. "We're developing all this really wonderful tech and almost all of it demands our attention," he says. "We build a navigation system, but then we have to stare at it."

"Their goal is letting you use your attention on what you want to use it on," says Peck. "It's in your hands now." ■

HAND-HACKING TEACHES NEW TRICKS

Tweaking a person's muscles using electrodes (see main story) is precise enough that a computer can now guide us through unfamiliar tasks.

Pedro Lopes and Patrick Baudisch at the Hasso Plattner Institute in Berlin, Germany, have designed an electro-stimulation system attached to arm muscles that tells the wearer how to use an object. A can of spray

paint fitted with an RFID tag that talks to the system can tell people to shake it before use, say, while a knife tells people how to cut an avocado. It will be presented at the CHI conference in Seoul next week.

"We're moving away from processing things with our eyes and brain towards feeling things," says Baudisch.

INSIGHT Live-streaming

Smartphone spectators

When will apps like Periscope get interesting, asks **Aviva Rutkin**

BORED, standing in a long line at the doughnut shop, I invited the world to come stand in line with me. I whipped out my phone, opened up the Periscope app and panned slowly over the glass window of delicacies. Within a few seconds, there were a dozen strangers peering through the camera. They issued demands in the bottom left corner of the screen: "Point it over there!" "Get glazed." "Where am I?"

Such is the strange world of live-streaming. In the last few weeks, two apps have launched that let people easily share what's going on around them in real time. With Periscope and Meerkat, you can dive into one of the streams beaming from smartphones around the world, or broadcast your surroundings for others to see.

So what on earth should we do with it? Neither Meerkat nor Twitter, the company behind Periscope, are the first to try their hands at

live-streaming. Protests around Ferguson last year and Occupy Wall Street in 2011 were aired live through sites like Livestream and Ustream.

But now, live-streaming seems to be having a moment, says T. L. Taylor at the Massachusetts Institute of Technology, who's working on a book on the subject. These apps have made it easier than ever to do it yourself.

"We've gotten to a point where it's fairly easy to do technologically," she says. "Things are really shifting and developing quickly. It's an exciting time to watch it."

First using Periscope, I wasn't sure what to expect. I looked out of the window as someone drove through San Francisco. I waited for the Tokyo

subway. I saw lots of pets, usually asleep, their owners cooing behind the scenes. The experience was intriguing, but also underwhelming.

The problem is that we're still figuring out when to use these apps and how to do it right. During one of my streams, for example, I was briefly chastised by a viewer for holding my phone sideways rather than upright.

While this trend is in its infancy, the moment is ripe for experimentation – whether that means Swedish cooking shows, walking tours of New York City or watching astronaut Chris Hadfield describe his spacesuit. (All things that people have already tried.)

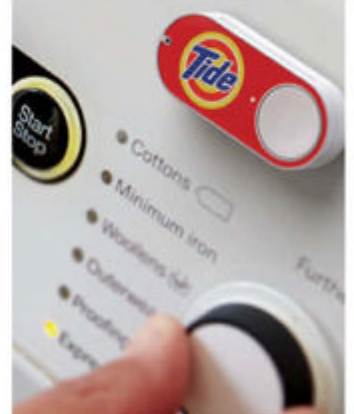
Users are still trying to see what works, says Jeetendr Sehdev at the University of Southern California in Los Angeles. "No one really knows what sort of live-streams are going to catch on."

Down the line, Sehdev thinks that success on the apps will be about the bond that viewers feel with the live-streamer. On other video services like Vine, YouTube and Snapchat, ordinary people have accrued millions of followers and expensive ad deals by sharing their lives online. A year from now, we might well be writing about the first breakout crop of Periscope stars.

Periscope has already proved itself useful for journalists, too. Last week, a gas explosion knocked down several apartment buildings in New York City, and a streamer was there to put viewers on the scene. The apps make it easier to get breaking news out on social media fast, and harder for troublemakers to spread false information, says Jeff Howe, a journalism professor at Northeastern University in Boston, Massachusetts.

"The crowd is great at being at the right place at the right time and happening to have a smartphone," he says. ■

ONE PER CENT



Dash to the shop

About to run out of toilet paper? Don't panic. Last week Amazon unveiled Dash, a plastic button that orders specific items to your door with a push. Each button is preset for a particular product, and connects to Amazon via Wi-Fi. Users can stick the buttons next to their stash of products that will need restocking – nappies, laundry powder, Gatorade – then press to order more when they run low.

"Cyber threats pose one of the most serious economic and national security challenges to the United States"

Barack Obama declares a national emergency to deal with the threat of online attacks

Under Google's knife

First search, now surgery? Johnson and Johnson announced last week that its subsidiary Ethicon has teamed up with Google to build advanced surgical robots. The idea is to use Google's data-gathering abilities to give surgeons better imaging and analysis tools when they operate robotically. The move follows Google's and Apple's initiatives to gather medical data with their devices.



My stream of consciousness



Support for ISIS is strong

ISIS tweets reveal secrets

Mining Twitter shows how Islamic State spreads, finds **Niall Firth**

WE KNOW only too well the power that Islamic State wields on social media. After every atrocity, slickly produced images and video quickly circulate online.

The jihadist group is also expert at using social media for propaganda and recruitment. But now a closer look at ISIS-affiliated Twitter accounts is giving intriguing insights into how the group governs its territories.

Aymenn Al-Tamimi, an analyst for the Philadelphia-based think tank Middle East Forum, has been studying ISIS tweets since about April 2013. "That's when you begin to see the trappings of some kind of proto-state," says Al-Tamimi.

A report in March by non-profit group the Brookings Institution in Washington DC showed that ISIS supporters operated more than 40,000 Twitter accounts last year. Most are of no use to researchers, says Al-Tamimi. He is interested in those that originate in territory that ISIS occupies, and which have published documents that give insight into how ISIS operates. For

example, some describe the state institutions and new laws that ISIS introduces. Documents include a new curriculum for the University of Mosul in Syria, which cancels all lessons in philosophy, English or French literature and tourism. Another account operated by ISIS administration in Iraq issues strict new rules about subjects as prosaic as how waste should be disposed of: a 5000 dinar fine (£3) is to be levied for throwing litter from a car; a 25,000 dinar fine is imposed on fly tippers.

Other tweeted documents are

more surprising. One details a vaccination timetable for children. This suggests ISIS is a more modern group than the Taliban, says Al-Tamimi. The Taliban banned vaccinations in Helmand province in Afghanistan last year over fears of spying.

The same move towards the apparatus of a state has been seen in Ar Raqqa in northern Syria, the group's de facto capital, where the education department is putting into place school curricula, and arranging sharia sessions for teachers. The posts

THE WAR ONLINE

The war against ISIS isn't just taking place on the ground. Hacktivist collectives Anonymous and GhostSec have been taking down ISIS websites by using DDoS attacks to overwhelm them with traffic.

They have also released lists of Twitter accounts affiliated with the group. Last month, hackers released a list of 9200 suspect accounts.

As a result, ISIS issued its followers with a social media guide showing them how to bypass having to give phone numbers and email addresses when signing up for a new Twitter account. There has also been suggestions that ISIS is using the "dark net", via anonymising software Tor, to recruit and to share images.

also show how ISIS is unable to provide electricity for some of its territories and that there are shortages of medical supplies.

For Al-Tamimi, these attempts to provide a governmental framework help ISIS control its territory, and might explain its dominance over other groups in Syria. "It's a lot more complicated,

"ISIS's model brings a sense of order rather than civil war. That's why they don't really have local rivals"

much more developed," he says. "The model we see brings a sense of order rather than civil war, that's why you don't really have any local rivals."

It might also make the West pause if it wants to arm rebel groups against ISIS. "In Syria, the locals will not welcome local rebels if they cannot offer a viable form of governance," says Al-Tamimi. Air raids will only go so far. "You can't just drive them out, you have to offer some sort of governance. Just bombing places to oblivion is not going to help."

Looking at how ISIS develops could also reveal how the group's methods are being copied in other areas, such as in Libya and with jihadist group Boko Haram in Nigeria, he says. In Derna in eastern Libya, moves to create education departments show how advanced the group's presence in the region is. And long before Boko Haram pledged allegiance to ISIS, its official Twitter feed was co-opting songs and videos produced by ISIS.

"We can learn a tremendous amount about ISIS from social media, but you have to approach the material with a sceptical eye," says J. M. Berger of the Brookings Institution. "No other extremist group has so many people dedicated to social media activism, working in such a coordinated way," he says. "Social media information can make ISIS look bigger and more powerful than it really is." ■

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A chill wind

IT CAN get pretty cold on the summit of Mount Washington, or Agiocochook as Native Americans call it. The New Hampshire peak stands at 1917 metres and is the highest in north-eastern US. It also has the distinction of hosting the Mount Washington Observatory, which was the world's first mountaintop weather station. Meteorological data has been gathered there since 1870.

Hard rime - the combs of ice seen in this image - features large. This kind of ice forms when water in the air freezes to rocks or trees facing into the wind. As well as being cold - it was -44°C when this photo was taken in March - it gets windy. In 1934 the observatory clocked what was until 1996 the world's fastest recorded wind speed, 372 kilometres per hour. If you visit, don't forget to wrap up warm. Rowan Hooper

Photographer

Robert F. Bukaty AP Photo

Extremism's false trail

Violent ideologies don't ensnare young people for the "obvious" reasons, says **Kamaldeep Bhui**

THERE was great unease when it emerged that Mohammed Emwazi, the masked figure who appeared in Islamic State videos in which hostages in Syria were beheaded, was educated and raised in the UK. A similar reaction followed the 7/7 bombings of 2005 and the 2013 murder of soldier Lee Rigby in London.

All these events prompted wild speculation about what led those responsible to risk death, commit criminal acts and turn their backs on family, friends and a relatively comfortable life in the UK – a place that offers ready access to education as well as medical and social care. They exemplify a worrying trend for individuals here and in other democracies to turn against their societies, sometimes killing fellow citizens at home or abroad.

Despite efforts to prevent radicalisation, there has been a steady stream of young people travelling to Syria to join the jihadists. The International Centre for the Study of Radicalisation, part of King's College London, estimates that more than 20,000 people from around the world have done so, including more than 500 UK citizens and at least 3000 from the rest of Europe. Among them are a growing number of women and girls, some as young as 15.

One attempt to explain their choice argues that they have simply succumbed to a persuasive ideology about establishing an Islamic state, one transcending the borders of nation states, in a campaign dressed up as a religious war. Loyalty to this



imagined new state paves the way to being disloyal to your own.

Others suggest that radicalised people are angry about their own living conditions, discrimination, poverty and unemployment, or possibly reacting to unjust foreign policy. In this picture, turning to terrorism is an act of protest.

Such explanations may dominate, but they lack evidence. My colleagues and I have used a public health approach to better understand what really puts people at risk of radicalisation.

The science of public health allows us to assess what happens when harms threaten society, and to try to identify risk factors and resilience factors. We can then

target those factors to improve health. This has proved to be a powerful route to a safer world, and has already been applied with some success to preventing suicide, violence and mental illness. Could we do the same thing with radicalisation?

Research in the US following the 9/11 attacks suggested that having sympathies for terrorist acts and violent protest is a sign that people are susceptible to future radicalising influences. We took that as our starting

"We have found that frequency of religious worship is not correlated with extremist leanings"

point and assessed these kinds of sympathies in men and women of Pakistani and Bangladeshi origin living in the UK.

We found that these views were uncommon – they were held by just 2.5 per cent of our sample – and were unrelated to poverty, political engagement, or experience of discrimination and adversity. However, we did find a correlation between extremist sympathies and being young, in full-time education, relative social isolation, and having a tendency towards depressive symptoms.

In contrast, we found that being born outside the UK, general ill health or having large social networks were all associated with moderate views. We also found that women were as likely as men to hold extreme sympathies, although the association with depression was stronger in men. Frequency of religious worship and attending a place of worship were not correlated with extremist leanings.

Such findings challenge many of the pervasive ideas about what drives radical beliefs, including the notion that religious orthodoxy fuels extremism.

Depressive symptoms fall squarely into the health arena. We know that any form of depression is associated with negative sentiment, including a sense of hopelessness, worthlessness and helplessness. Such an outlook can fuel thoughts that suicide is a solution.

Depression can also leave people feeling irritable and aggressive.

We also know that half of all cases of long-term mental illness

develop by the age of 14. Are we overlooking subtle varieties of psychological distress that do not meet diagnostic thresholds, but can still devastate young people's schooling and relationships and leave them vulnerable to radicalisation? We will need to identify these young people and make sure we better understand the extent to which depressive illness, a pessimistic outlook and social isolation raise the risk of being radicalised.

Given what we know about young people's impulsive decision-making and the difficulty they have in forecasting consequences, these people may seek solutions they mistakenly think will empower them. For example, a search for sacred meaning may lead them to commit to terrorist causes, just as some might join a gang to bolster self-esteem and for protection.

This is a complex issue, and of course peer pressure can play a part in swaying choices, as can online information and social networking. Healthy sources of self-esteem, authentic religious teaching and social support are known to buffer the risk of joining gangs, and are also likely to be important in fighting extremism.

Encouraging young people to learn about risky behaviour and pitfalls they might be vulnerable to, and about morality and spirituality and ways of growing well, are mentioned in the UK's Counter-Terrorism and Security Act 2015. This is a good idea.

Reframing the conversation on radicalisation, from one about criminal justice to one focused on the health of young people, might also help address some opposition to existing strategies.

We hope our paradigm offers a way to find out why some people are more easily radicalised, and that this will help stop yet more following this destructive path. ■

Kamaldeep Bhui is professor of cultural psychiatry and epidemiology at Queen Mary University of London

ONE MINUTE INTERVIEW

The moral of the coral

Widespread bleaching of coral reefs is a clear sign of where our warming world is heading, warns **Ove Hoegh-Guldberg**



PROFILE

Ove Hoegh-Guldberg directs the Global Change Institute at the University of Queensland, Australia, is chief scientist for the Catlin Seaview Survey and a coordinating lead author of the oceans chapter in the IPCC's Fifth Assessment Report

How are you keeping tabs on coral?

The Catlin Seaview Survey (CSS) has captured 800,000 images of coral reefs from 22 countries in four years. It's the largest stocktake of the health of reefs worldwide in history. Right now we have an expedition in the Maldives. We really want to get good baseline data as we start to see the next coral bleaching event.

Why should we focus on coral reefs?

These reefs create a microcosm story: they are a metaphor for where the world is going, and one of the strongest signs of an impact of climate change on ecosystems. Over the last 30 years we've lost coral at an incredible rate – about 40 per cent of it globally. One in every four species in the ocean lives on a reef, and we're taking away that habitat.

What causes coral bleaching?

It happens when the sea temperature reaches roughly a degree warmer than the long-term summer maximum and stays there for four to six weeks. Corals can survive it, but if the event goes

on longer, or the temperature climbs higher still, you get mass mortality. Over the last 12 months seas have come very close to that threshold. We're on the brink of a major, worldwide bleaching event, says the US National Oceanic and Atmospheric Administration's Coral Reef Watch programme.

Are these events becoming more common?

Once, it might have taken the extra ocean warming of an El Niño to cause bleaching, but we're now getting to the point where even regular temperatures are getting high enough. When we predicted this in 1999, I became a pariah. People were saying "No, that's not possible." But it's coming true – no one's been able to knock that idea off. And I think that 20 years from now, every summer will be too hot for corals: they will disappear as dominant members of tropical reef systems by 2040-2050. It's hard to argue it any other way.

How can we peer beyond that bleak outlook?

Lots of people say to me, "God, you're a depressing bastard." But this is the scientific reality. What we're hoping as we head towards this year's climate summit in Paris is that we can bring this startling issue to the fore. The CSS now has a rapid-response capacity; we can quickly send people and recording equipment to bear witness to the actual moments of bleaching. The death throes of coral are, sadly, quite beautiful events.

Where is the beauty in dying coral?

It happens over a week, but there comes a moment when suddenly reefs just go from being brown – from all those symbiotic algae inside their tissues – to these beautiful white translucent colours, when the algae are expelled. Pink and purple animal pigments in the coral produce beautiful fluorescing patterns. On the southern Great Barrier Reef we had some localised bleaching, and dive companies were encouraging people to come to see the fluorescing corals. I understand why they did it, but it was bizarre – like partying at a funeral.

Interview by Sean O'Neill & Catherine Brahic

Your world will be hacked to pieces

The shiny technology that is rapidly transforming our lives has a dark, terrifying underbelly, warns **Marc Goodman**

Your new book is called *Future Crimes*.

How is crime changing?

In the old days, you buy a gun or a knife, you go hide in a dark alley until some sucker walks by and you say, "Give me your wallet". Good business model, but you can only rob four or five people a day. However, with Moore's law of technological progress comes Moore's outlaw, and so we're seeing a paradigm shift in crime. In one hack of the US retailer Target in 2013, over a third of Americans were victims, including tens of millions of people who had their bank details stolen. So one individual can now rob 100 million people. That has never been possible before and it's because we're all connected via vulnerable technology.

You started out as a police officer. How did you become interested in cybercrime?

I was the technical genius in the Los Angeles Police Department who knew how to use spell-check. I did the local policing thing, then I worked with Interpol for over 10 years, helping police forces around the world deal with cybercrime. As I got more into these cases, I saw how the bad guys were exploiting tech. In the late 80s and early 90s, when pagers were not yet that common, I saw gang members and drug dealers carrying them. Criminals had cellphones long before any cop did. Criminals are often early adopters of technology.

What technology have criminals adopted now?

Hacking itself has been encoded in software. If you wanted to hack into a bank 20 years ago, you'd need to be a master hacker. Now you can pay a fee to the master hacker, who has encoded his knowledge into crimeware. Most hacking attacks are no longer carried out by

humans. That Target hack was carried out by a 17-year-old kid in Moscow who bought some software online that broke into the network.

You've called cybercrime a gathering storm.

What's about to happen?

The internet is about to get a whole lot bigger. It's like the old days when London or New York ran out of telephone numbers and they needed to create new area codes. We're doing the same with the internet and the impact will be massive. The old internet could support 4.5 billion simultaneous connections, but the new addressing system being rolled out – Internet Protocol version 6 – supports up to 78 octillion. That's 78 billion billion billion things that can be connected to the internet at

"If today's internet is the size of a golf ball, it will soon grow to the size of the sun"

once. So if today's internet is the size of a golf ball, in the next few years it could grow to the size of the sun. Every grain of sand on our planet could have its own internet address a trillion times over. Previously, I never had to worry about a hackable television, a hackable pacemaker, a hackable car, a hackable pet. But now all of this is possible. We've wired the world but failed to secure it.

You're implying that every connected device is a target. Why do you think that?

No one has ever built a computer system that could not be hacked. We are rushing full speed ahead to put every possible device online and they're all insecure. We should pause for a moment. If somebody hacks my television,

do I care? But all of the world's critical services are run by computers and we're seeing these computers increasingly come under attack. People have always struggled for power. Now, if you control the code, you control the world.

Does that include connected technology like CCTV security cameras?

The tools we have to protect us can be subverted and that security used against us. It's what I call the judo model of cyber security – using your opponent's weight against them. You really can't have any faith that when you set up 300 cameras on a street in London, or wherever, that the government is the only one watching.

Nor can anyone trust what they see on screens. We've all received phishing emails that appear to be from our bank. That was taken to the next level with the Stuxnet malware attack in Iran in 2010. Nuclear engineers in a control room were staring at screens that showed the status of uranium-enrichment centrifuges. The screens said everything was fine but the centrifuges were actually spinning out of control. Somebody had inserted a hack in between what was really going on and what was being presented on the screens. We are becoming increasingly disconnected from physical reality in this way.

It's often said that we're the weakest link when it comes to security. Is that fair?

If you're content to not understand anything about technology and you're happy just pushing the little buttons on your iPhone, then you're at risk. Somebody else in Moscow or Guatemala understands exactly how that phone works and will use that against you. We need to give people a sense of cyber hygiene. ➤



PROFILE

Marc Goodman has spent decades in law enforcement and technology, and worked with the FBI and Interpol. His new book is *Future Crimes: A journey to the dark side of technology - and how to survive it* (Bantam Press)



In the real world, I cover my mouth if I sneeze. But we have no idea what hygiene looks like in cyberspace and so we continue to spread “disease”: we send around email attachments that have viruses and we plug strangers’ USB sticks into our computers.

However, one of the reasons why we have these fundamental risks today is bad software. I get that coding is complex, but Facebook’s motto used to be “Move fast and break things”. In other words, speed to market is more important than security. Blaming humans rather than poor security design is bullshit.

If we fix cyber security, can we stop worrying?

The threats that we’ve been talking about are all behind computer screens. If somebody takes £50 out of your bank account, you’re not physically harmed. But a fair percentage of the devices we’re about to connect to the internet will be robots that can move. We’re about to introduce millions of computers that walk, crawl, roll and swim. They will fly above us like drones, follow us in swarm formation, track us down the street. Robots can kick, punch and shoot – and they can all be hacked.

We’ve already seen examples of people using drones. The FBI arrested a young man called Rezwan Ferdaus who was planning to load drones with explosives and fly them into the Pentagon and the US Capital building. We’ve had peeping Toms. In Seattle, a woman was changing with her curtains open on the 25th floor of her building – something she’d

never had to worry about before – and looked out her window to see a drone filming her. If you call the police and say, “There’s a drone outside my apartment”, what are they going to do? The tools aren’t there at all.

What about synthetic biology? Presumably you see problems there too...

Where do I begin? If you can code in DNA, you can hack DNA. The recipes for bioweapons like Ebola and Spanish flu are all online. The cost of synthesising them has dropped sharply and our ability to decode DNA is proceeding at a pace five times that of Moore’s law. With the tens of thousands of people experimenting with this technology, it wouldn’t be surprising if there were a few bad apples.

Another possibility is attacking a specific individual. If you can come up with a personalised cancer treatment (see *New Scientist*, 13 December 2014, p 28), you can come up with a bioweapon tailored to attack that person’s genetic code. We’re completely unprepared for these eventualities.

You’ve painted a vivid picture of future crime. What will future policing look like?

All of these crime bots are running amok, but we don’t have the cop bots to take them out. Robotics could be huge for policing – you could automate the bobby on the beat. And on the AI front, we should take advantage of big data for crime solving. We’ll also see a lot of the military technology that’s being developed –

armed robots, aerial drones – coming to civilian law enforcement. The modern police force is already being militarised. There are definitely changes coming.

It sounds like a lot of resources will be needed to tackle these issues. Is that why you’ve talked about the need for a new “Manhattan Project”? The wonderful technological future that we’ve been promised by Silicon Valley won’t come for free. It’ll take time, money and effort. But think about the existential risk that the Allies faced in the second world war – the prospect of the Nazis developing the nuclear bomb first. It galvanised them into action. During the Manhattan Project, the Allies had more than 110,000 people around the world working 24/7.

I use that comparison because we have just as much at risk. I think about the fact that the internet is at the core of the world we are building – fundamental to our electricity grids, national defence, healthcare and transportation. I think about having no electricity, no running water and sewage leaking on to the street because these systems have been hacked. It focuses the mind.

So why isn’t society being galvanised into action by this “gathering storm”?

The difference between the people of Manhattan Project and us is that they were serious about the threat before them. ■

Interview by Douglas Heaven

Not to be sneezed at

Hay fever and other airborne allergies are often trivialised. But they're a big problem – and getting worse, says [Linda Geddes](#)



FOR many of us, the misery descends in early spring and doesn't lift until the nights start drawing in. Even then, the dust and fungal spores of autumn may bring fresh aggravation. Whether it's itchy eyes, a streaming nose, disturbed sleep or uncontrollable sneezing, hay fever and other airborne allergies are one big irritation.

Often, they're dismissed as just that. Yet mounting evidence suggests we should be taking airborne allergies – aka allergic rhinitis – more seriously. Adults with moderate to severe hay fever take an extra four days off work per year on average, and may be less productive for up to 38 working days. Teenagers plagued by symptoms during



exam time are significantly less likely to achieve their predicted grade, and people who get behind the wheel with untreated hay fever can be as dangerous as a drunk driver. "People trivialise hay fever, but it can impact many important things in life, including your quality of sleep, concentration, social interactions and self-esteem," says Jean Emberlin, scientific director of Allergy UK.

Worse, there's a growing consensus that uncontrolled hay fever can develop into a genuinely life-threatening condition: asthma. With such allergies on the increase, and the pollen seasons supposedly getting longer and more intense, is there anything we can do to defend ourselves – and our children – against this annual peril?

Grass pollen is by far the most common cause of hay fever...



ALDO SPERBER/PICTURE/TANK

What happens when an allergy kicks in?

Whether to pollen, mould, dust, fungal spores or animal dander, all airborne allergies have the same root cause: the immune system responding inappropriately to a harmless substance, or allergen. How that inappropriate response develops is a matter of debate, but the results are predictably unpleasant.

Because airborne allergens are breathed in, they tend to hit the upper airways hardest. When a pollen grain lands on the damp lining of the nose and throat, its tough outer coat can burst, releasing its contents, including allergenic proteins. These come into contact with immune cells called mast cells, which are the body's first line of defence against invaders.

In most people, these harmless proteins are ignored, but those with allergies are not so lucky. Receptors on the surface of their mast cells bind to the offending proteins, prompting the release of histamine, which triggers explosive sneezing and the secretion of fluid to flush the invader out of the body. "It's like a grenade going off in the nose; you get this immediate release of histamine and within 30 seconds you're sneezing," says Stephen Durham, professor of allergy and respiratory medicine at Imperial College London.

There are also mast cells in the lining of the eyelids, which helps explain the inflamed and itchy eyes. This reaction is exacerbated by something called the naso-ocular reflex. When

"It's like a grenade going off in your nose; within 30 seconds you're sneezing"

the nerves linking the lining of the nose to the outer surface of the eye are irritated, you get reddening and itching of the eyes too.

That's just the start. Around 4 to 8 hours after coming into contact with an allergen, immune cells called T-cells and eosinophils also start to release prostaglandins and other substances that trigger inflammation and swelling, leading to blocked nose, painful sinuses, a general feeling of malaise and, sometimes, mental fuzziness.

What causes the immune system to go haywire?

The responses that cause the symptoms of hay fever are nearly identical to the body's mechanism for destroying and expelling parasites. How these reactions come to be triggered by innocuous substances like pollen is not well understood.

What is known is that the sensitisation process generally starts months or years before you notice any symptoms. The end result is a network of immune cells primed to react to specific allergens when you encounter them again in the future.

For some reason, more and more people are being sensitised. Allergic rhinitis affects people across the world but the highest recorded incidence among adults is 30 per cent in the UK, three times what it was in the 1970s. The US, Australia, New Zealand and other Western countries have experienced

KNOW YOUR ENEMY

Hay fever gets its name from its long association with the summer haying season, when farmers cut grasses to store as fodder. The condition was officially recognised in 1819, when John Bostock, a doctor from London, wrote up his own symptoms in one of the journals of the Royal Society of Medicine. Bostock described it as an "unusual" condition but by the end of the century it was common across Europe and North America.

Hay fever is not specific to hay or the haying season; almost any pollen from a wind-pollinated plant can cause it, at almost any time of year.

The most common troublemakers are trees – especially birch – grasses and weeds (see "Allergy in the UK", page 37). Grass pollen allergy is by far the most common, but there are tens if not hundreds of known allergenic pollens and many people are allergic to two or more.

It doesn't take much to trigger a reaction. Symptoms typically kick in once the pollen count reaches 50, which means there are 50 grains of pollen per cubic metre of air. To put that in perspective, a single ragweed plant can release 2.5 billion pollen grains a day. Graham Lawton



... but tree pollens such as hazel are also an irritant for many

might lower the diversity of microorganisms living in and on us, and that this might tip the immune system towards an allergy-prone state. Ilkka Hanski at the University of Helsinki in Finland recently discovered that, compared with healthy individuals, people who are predisposed to developing allergies are more likely to live in built-up areas, and have less-diverse bacteria living on their skin.

One group of bacteria called *Acinetobacter* looks especially interesting because it seems to encourage immune cells to produce an anti-inflammatory substance called IL-10. "Children growing up in homes that are surrounded by more forest and agricultural land tend to have more of these bacteria on their skin, and lower rates of allergy," Hanski says.

Other possible factors that increase susceptibility include greater use of antibiotics during childhood, lower levels of vitamin D or exposure to certain chemicals. For now, nobody really knows.

Are allergy seasons getting worse?

The distribution and abundance of allergy-inducing pollen is changing, and this could certainly play a role in the hay fever epidemic – perhaps, as a result, more people are becoming sensitised or are seeking treatment for worsening symptoms.

Last September, invasive super-pollens made the news in the UK after they were detected in central England. The offending pollen was ragweed, a long-standing scourge for Americans with hay fever that has recently become established in parts of central and southern Europe – which is presumably where the pollen blew in from. Whether ragweed will establish itself further north is up for debate. "It's a very plastic plant; it can survive at cooler temperatures, but whether it can prosper is another question," says Roy Kennedy, director of the National Pollen and Aerobiology Research Unit in Worcester, UK.

Climate change could also be a factor, shifting the distribution of allergenic plants such as olive trees, which are a major cause of hay fever in Spain, and subtropical grasses, which are a problem in northern Australia. "With climate change, we are likely to see a spread and change in distribution of the types of grass pollen, with subtropical species that flower predominantly in summer coming in to play in more temperate regions," says Janet Davies at the University of Queensland in Brisbane. If such plants then flower at different times, this could extend the

similar growth. The global average is about 16 per cent, meaning that more than a billion people have hay fever.

Some figures suggest it is more common among teenagers, and hay fever often first raises its head during the teen years. But symptoms can suddenly start at any time of life, even in old age. Quite why it can take so long to come to a head isn't known. "It could be due to changing hormone levels, or it may simply take time for sensitisation to develop," says Durham. Drinking alcohol and smoking also increase the risk of developing hay fever and make symptoms worse.

What's behind this epidemic? Increased awareness could be part of it, but that's not the whole story – allergies of all kinds have seemingly become more common in recent decades.

The leading explanation is the hygiene hypothesis – the idea that decreased exposure to bacterial infections and parasites during early childhood disrupts the normal

development of the immune system, causing it to pick fights with harmless substances.

Growing up on a farm seems to protect children against hay fever and asthma, as does drinking unpasteurised milk.

But the hygiene hypothesis is not a complete explanation either. Certain countries such as Japan are extremely Westernised yet have very low rates of

"Getting behind the wheel with hay fever can be as dangerous as being drunk"

allergy – possibly because of underlying genetic factors that influence susceptibility. If you have one close family member with hay fever, you have a greater than 50 per cent chance of developing it yourself.

One recent twist is the suggestion that reduced contact with natural environments

hay fever season for people who become sensitised to them.

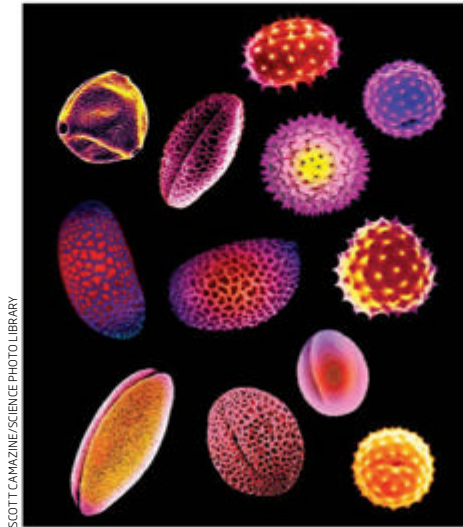
The flowering seasons of individual species could also change; one recent study found that the annual length of the ragweed season increased by between 13 and 27 days from 1995 to 2009 in certain regions of North

“Warmer temperatures and increased rainfall can ratchet up the agony”

America. Similarly, the UK’s birch flowering season – typically in late March – started five days earlier each decade between the 1960s and 1996 due to milder winters and warmer springs.

Warmer temperatures and increased rainfall can ratchet up the agony for allergy-prone people in other ways too. When pollen gets wet it’s more inclined to burst in the air, making it easier to inhale the allergens. That may be why symptoms are often worse in the morning, when mists and dew are more common. But dry weather also causes pollen grains to shrink and burst, which is why symptoms often peak around midday when humidity levels drop.

Changing weather patterns are another



SCOTT CANAZINE/SCIENCE PHOTO LIBRARY

factor. Pollen tends to be released in the early morning, but because it is designed to be blown far and wide by the wind, levels can be high at any time of day.

Under certain climatic conditions, pollen, dust and other particles can get swept up into the atmosphere and travel long distances. “Often people will blame their neighbours’ trees for their allergies, and these may have some influence, but you also get pollen clouds

blowing across countries,” says Tariq El-Shanawany, a consultant clinical immunologist at Cardiff University, UK.

Pollution can exacerbate hay fever by making the linings of our noses and lungs more permeable to allergens and by physically modifying allergens to increase their potency. Ozone, for example, seems to trigger the production of reactive oxygen species within pollen grains, and exposure to these highly reactive chemicals is more likely to prompt immune cells to respond.

Pollutants may also make pollen more potent by causing allergens to leach out onto the surface of the grains. A recent study found that birch pollen collected from trees in Munich, Germany, was more likely to provoke an immune reaction than pollen collected from trees in rural areas.

Do allergies change over time?

Many people find their hay fever symptoms dwindle as they age, although no one knows why. But allergies can and do get worse over a lifetime, and there are reports of people who are middle aged and older suddenly developing hay fever having never been sensitive to pollen before.

It’s also true that if you’re unfortunate enough to have one allergy, you are more likely to develop others. This is in part down to basic biology: some people simply have an immune system that is more allergy-prone. “If you’ve got an allergy, you’ve got that combination of genetic susceptibility plus environmental exposure, and it’s that combination that produces an allergy,” says El-Shanawany.

Not only that, immune cells sensitised to one allergen can cross-react with other related proteins, meaning allergies can “spread”. For instance, some of the proteins in birch pollen are closely related to those in alder and hazel, which peak around a month earlier, potentially prolonging the agony for someone sensitised to birch.

Foreign travel is another thing that can foster the development of new allergies. “If you travel to southern Spain in spring and there is a lot of olive pollen then you could become sensitised to it within days,” says Emberlin. “Olive pollen cross-reacts with ash, so you might come home and find that you start getting a reaction to ash trees.”

It’s not just other pollens you can find yourself sensitised to if you have hay fever – the condition can trigger cross-reactions to foods. For example, a birch pollen allergen



LARRY TOWELL/MAGNUM PHOTOS

Growing up on a farm seems to protect against allergy to pollen grains (above)

called Bet v 1 shares similarities with proteins in some fruits and nuts, and so people with hay fever may occasionally notice swelling and itching in their mouth when they eat uncooked fruits like as apples, peaches and kiwi. Hazelnuts, almonds or even soya milk can trigger it too.

Similarly, people with an allergy to house dust mites may find they develop reactions to crustaceans. This is called oral allergy syndrome, and is usually harmless – but not always. One study found that oral allergy symptoms spread to other areas of the body in nearly 9 per cent of people with the condition, and progressed to anaphylactic shock in 1.7 per cent of them.

Then there's asthma. Hay fever is a disease of the upper airways whereas asthma is one of the lower, characterised by inflammation, muscular contraction and the production of mucus. However, having hay fever roughly triples the risk of developing asthma and there's a growing sense that the two conditions are different manifestations of the same disease.

"If you have uncontrolled hay fever and you are reacting to pollen, a chemical cascade is developing in your nose and to some extent in the rest of your body that can ultimately recruit reactions in the lungs," says Emberlin. "You will get a tendency towards having asthma."

Can airborne allergies be cured?

In some cases, yes. Sometimes they disappear of their own accord, and there are effective drugs for managing the symptoms, including tablets and nasal sprays.

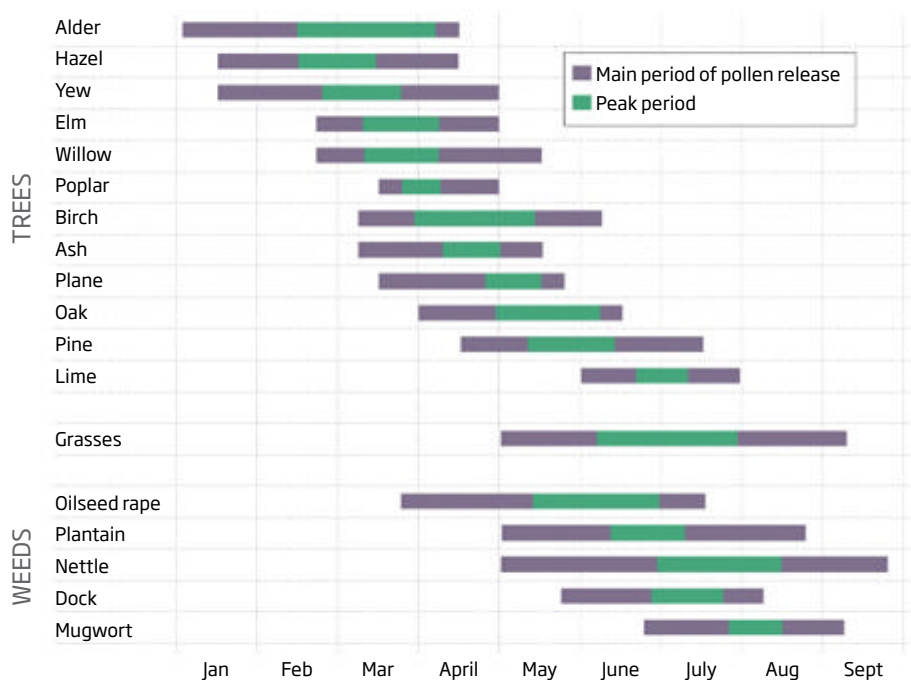
For some poor souls, however, the symptoms never let up and even regular and correct use of these medicines isn't enough to offer relief. That's where a relatively new treatment called immunotherapy may help.

Unlike antihistamines and steroid sprays, which merely dampen the immune system's reaction to allergens, immunotherapy is designed to retrain it. In some cases allergies can be completely cured this way.

The treatment involves regularly exposing the immune system to high doses of the problematic allergen in order to desensitise it, although exactly how it works is unclear. The thinking is that when B-cells and T-cells in the lymph nodes are exposed to high levels of allergen, this prompts them to do a U-turn; instead of churning out chemicals that rally immune cells to their defence, they stimulate the growth of master immune cells called

Allergy in the UK

The main allergy-causing pollens in the UK are released over different periods. This means that for some people, the hay fever season can last 9 months



SOURCE: NATIONAL POLLEN AND AEROBIOLOGY UNIT, 2012

regulatory T-cells that dampen the response.

For now, most immunotherapies involve a three-year course of weekly injections into the fatty layer beneath the skin, or tablets placed beneath the tongue. This makes it time-consuming and expensive and means that many people stop before treatment is completed, or aren't offered it in the first place.

"If everything is done right, injected immunotherapy is extremely effective," says Hal Nelson, senior staff physician at National Jewish Health in Denver, Colorado. "But I think it's safe to say that it's rarely a

"The best thing you can do to protect your children is expose them to a cowshed"

lifetime cure. People can relapse, and the duration of remission will vary from individual to individual."

However, there's nothing to stop people going back for another course, and there's some evidence that the treatment doesn't need to be as prolonged the second time around, he adds.

What's more, two pilot studies have suggested that it's possible to induce tolerance to cat and grass allergens with just three injections into a lymph node in the groin. Other trials are investigating the use of skin patches or modified allergens that could be given in higher doses for shorter periods.

There's even hope that immunotherapy could halt the sensitisation process in its tracks in children who are likely to develop allergies – those with a family history or who have eczema, for example – but haven't yet developed symptoms. "We think that treating with immunotherapy early on would put a check on that progression to other sensitivities and worse disease," says Davies.

There are other things that parents can do to reduce the chances of their children developing hay fever. Breastfeeding is thought to help protect against all allergies, but it's no panacea. Children living in rural areas seem to get less hay fever than those growing up in urban areas. "The best thing you can do for your children to stop them getting allergy is to expose them to a cowshed for 1 hour in the first 6 months of life," says Durham. ■

Linda Geddes is a *New Scientist* consultant based in Bristol, UK

PATH TO ENLIGHTENMENT

WE HAVE become accustomed to the universe blowing our minds – perhaps too accustomed. Quantum weirdness – things like particles being in two places at once, or appearing to share a telepathic link – has been baffling us for more than a century now. The physicist Richard Feynman once said that nobody really understands the quantum world. Or as others have put it: if you think you understand it, then you definitely don't. So it is tempting to throw up our hands and say human brains can never grasp it.

But maybe we shouldn't be so defeatist. Isn't it just possible that we simply haven't yet got to the bottom of how quantum mechanics really works? That's what Giacomo Mauro D'Ariano of the University of Pavia in Italy, and his colleagues Giulio Chiribella and Paolo Perinotti think – and they have been doing something about it. They have come up with a non-weird foundation from which all quantum weirdness can arise. Although very much a work in progress, it has attracted some very positive attention. "Their work and their approach is extraordinary," says theorist Lucien Hardy of the Perimeter Institute in Waterloo, Canada. Caslav Brukner, a physicist at the University of Vienna, Austria, is equally impressed. There's "something deep about quantum mechanics" here, he says.

For D'Ariano, it all started more than a decade ago, when students asked him to explain where the laws of quantum physics come from. It must have been tempting to dismiss it as a stupid question. Instead, he found himself at a loss for words. "I was very embarrassed," he says.

His embarrassment wasn't personal – it was for a whole field. Most physicists stand atop a firm foundation of physical principles: descriptions of how the physical world works. Take Newton's law of gravitation, which states that two bodies attract each other according to the size of their masses and the inverse square of the distance between them. That physical principle, encapsulated in a neat equation, tells you everything about classical gravity.

Explaining quantum weirdness is just a matter of perspective, says
Anil Ananthaswamy

In quantum theory, there are just the neat equations, developed not to encapsulate some universal principle, but in an ad hoc way to "explain" weird experimental results. Quantum objects are described by wave functions that might or might not correspond to anything physical, and which exist in an abstract, multidimensional domain called Hilbert space. What is more, they evolve according to abstruse rules laid down in the Schrödinger equation. Erwin Schrödinger came upon this formulation haphazardly in 1925 by studying the equations of classical optics, which dealt with waves rather than particles. It works well, but it's not quite clear why. "He didn't derive the equation from principles," says D'Ariano. There seems to be precious little physics in quantum physics.

Can we change this? Can the basic laws of quantum theory be derived from physical principles, rather than mathematical conjuring? D'Ariano, Perinotti and Chiribella believe the answer to these questions is a resounding "yes".

They are confident because the situation, though embarrassing, is hardly unprecedented. Newton's universal law of gravity allowed physicists to derive from first principles a series of serviceable, purely mathematical laws of planetary motion formulated a century earlier by the astronomer Johannes Kepler. Also, towards the end of the 19th century, the physicist Hendrik Lorentz, trying to accommodate contradictory experimental observations about the speed of light, proposed a set of mathematical conversion rules for observers moving in different ways through the universe. Lorentz's equations didn't stem from any fundamental understanding of light, but they worked.

It took Einstein to propose some physical principles – that the speed of light in a vacuum is constant and independent of the motion of the source of light – from which he was able to derive Lorentz's transformations. These became the principles of special relativity, which describes a universe where the laws of ►



physics are consistent for all observers. Eventually, this led Einstein to the even more overarching theory of general relativity, a theory of gravity that betters Newton's and works over cosmological distances. "It changed the way we are doing physics," says D'Ariano. "Principles are important."

Looking deeper

Can we pull off the same trick in the quantum world? "When I look at quantum theory, I see something that's akin to the ad hoc nature of Kepler's laws of planetary motion and of Lorentz transformations," says Hardy. "What we need is some deeper set of principles."

In the early 2000s, Hardy made his own attempt at coming up with some. It wasn't a full solution, he admits, but it inspired D'Ariano, Perinotti and Chiribella to dig deeper. "The idea was to somehow reprogram the genetic code of quantum mechanics, choose some physical properties and say, 'this is the fundamental thing', and re-derive the rest from it," says Chiribella, who is now at Tsinghua University in Beijing, China.

For both Hardy and D'Ariano's team, the "fundamental thing" has to do with information. Many theorists are coming to the

conclusion that physical interactions can all be described as a form of information processing. Atoms carry information in their momentum, for instance: when two atoms collide like balls on a billiard table, their momenta change in a way that is equivalent to the way binary digits change as they go through a computer's logic gates. Rules governing information manipulation could ultimately determine what does and doesn't happen in our universe.

D'Ariano's quest started back in 2003 with an effort to understand what informational rules might be common to both the everyday world and the quantum realm. Eventually, they came up with five fairly common-sense ideas that worked: things like ensuring the future can't influence the past (see "The Fivefold Way", right). Then they looked for inspiration to help describe features unique to the quantum world.

Several phenomena distinguish quantum from everyday, classical physics. One is superposition, where particles seem to be in two places at once, or spin clockwise and anticlockwise at the same time. Another is entanglement: two particles are entangled when measuring the properties of one instantly influences the properties of the other, no matter how far apart they are. Then there is the apparently random outcome of any measurement on a quantum system. You can't say what the result of any one measurement will be before you perform it; you can only calculate the probabilities of different outcomes.

To make sense of these quantum quirks, D'Ariano joined forces with Perinotti and Chiribella. Together, they saw a glimmer of an opening in the field of quantum information theory, and in particular a distinction that people who study this field make between different types of quantum state. For applications such as cryptography, they designate some states as "pure" – meaning that we know everything we can about such states. It is fairly straightforward, for example, to know everything about a single isolated

THE FIVEFOLD WAY

What are the basic rules about how the world works? Giacomo Mauro D'Ariano of the University of Pavia in Italy and his colleagues Giulio Chiribella and Paolo Perinotti have come up with five fundamental principles that must apply to any physical system to make a sensible measurement of it – as well as a sixth that they claim explains the weirdness of quantum measurements (see main story).

CAUSALITY

Stuff in the future cannot affect a measurement you're making right now.

DISTINGUISHABILITY

If a state is not too noisy, then there exists another state that can be distinguished from it.

COMPOSITION

If you know everything it is possible to know about all the stages of a process, then you know everything you can about the whole process.

COMPRESSION

There are ways to efficiently transmit all the information relevant to a measurement of a physical system without having to transmit the system itself.

TOMOGRAPHY

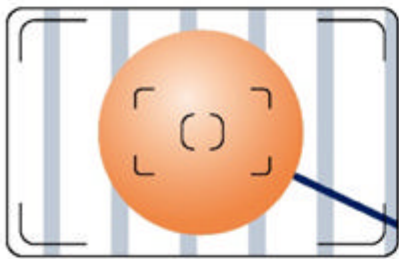
When you have a system with several parts, the statistics of measurements carried out on the parts is enough to identify the state of the whole system.

The big picture

Understanding quantum weirdness may be a question of getting the perspective right

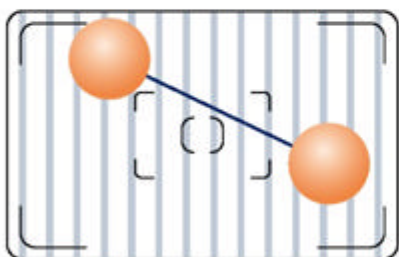
Focus too tight

Measure one particle's properties and the results may seem random. That's because it's really part of a wider system for which you don't have all the information



Proper perspective

Zoom out to measure properties associated with any linked particles and you find that measurements on the expanded system give you no surprises



"WHAT IF ALL THE MESSY UNCERTAINTY OF THE QUANTUM WORLD WAS DUE TO LACK OF INFORMATION?"

hydrogen atom in its lowest energy state: this is a pure state. Then there are "mixed" states, for which our information is incomplete. One particle of an entangled pair is in a mixed state: you can't know everything about one member of the pair without taking its counterpart into account.

But here's the intriguing point: both entangled particles together form a pure state. The two particles embody all the information

there is to know about the quantum system.

Could it be that all the messy uncertainty of the quantum world simply stems from lack of information: making a measurement of a mixed state without having access to the larger pure state of which it is part? "The idea is not to get rid of the weirdness, but to explain it as a logical consequence of basic principles," Chiribella says.

If every mixed state were part of a pure state, it would be possible to describe each physical process with maximum information. Take the existence of such a perspective as a principle – what Chiribella (who came up with the idea) calls the "purification principle" – and then it is always possible for someone with access to the pure state to make measurements consistent with those of less well-positioned observers who are dealing with mixed states. It doesn't make the weirdness go away, but it does make it explicable. It is like time dilation in special relativity, Chiribella points out. It is undeniably strange to us that time flows differently for people moving in different ways through the universe, but it still sort of makes sense. "Thanks to Einstein's principles



we know where it comes from and how to handle it," Chiribella says.

This in particular impresses Brukner. "I think the purification postulate is a deep statement that ensures that these two descriptions are consistent with each other," he says. By assuming it is something that is true of nature, D'Ariano and his colleagues were also able to derive much of the mathematics describing quantum oddities: things such as superposition and the Born rule, a mathematical trick used to calculate the probability of any particular outcome in a quantum measurement. They are working now on the Schrödinger equation, with no definitive success as yet – although they are encouraged by early results in which an equation of the right form pops out.

More tentatively, they also think the purification principle might illuminate another perennial mystery: the strange irreversibility of thermodynamics. All the basic equations of physics, whether quantum or classical, are reversible; you can run them from the past to the future or vice versa. The notion of reversibility "has been deeply rooted in the bones of physicists since the beginning

of modern physics", says Chiribella.

Except thermodynamics doesn't work that way. It is the study of energy transfer, and its effects on the arrangement of something like molecules in a gas. They can, for instance, be neatly ordered within a container, but you are much more likely to find them spread around haphazardly. That's because there are many more possible haphazard arrangements of the molecules than neat ones, and so the chances of the gas moving to a more ordered state are extremely low.

One-way street

Physicists' shorthand for this is the second law of thermodynamics, which states that entropy – the measure of a system's disorder – will always increase over time. For Chiribella, that might be an artefact of perspective because measurements made in thermodynamics always look at a subsystem in a mixed state, where we're not in possession of all the information. In other words, the laws of thermodynamics are what they are because we apply them to parts of a larger composite system. "It is a basic fact about quantum

theory: a noisy, irreversible evolution can be made reversible by including additional systems in the description," says Chiribella. So, on paper at least, irreversibility can be reduced to a reversible evolution. Whether this is the case in the real world is another question, but we do know that the fundamental laws of physics governing the microscopic world are reversible.

Not only are such connections still highly speculative, but the purification principle holds a sting in the tail, too, at least for

"IF THEY CAN GET THIS RIGHT, IT MIGHT PROVIDE MORE THAN JUST A JUSTIFICATION FOR QUANTUM THEORY"

quantum purists: it seems to side with the controversial "many worlds" interpretation of quantum mechanics. One of very many interpretations of the random outcome of quantum measurements, this argues that every possible outcome of a measurement does happen – and each happens in a different world, or universe. Take Schrödinger's cat, for instance, which notoriously can be simultaneously dead and alive unless someone looks to see what state it is in. In the many worlds scenario, the cat is dead in one world and alive in another. That fits in with the purification principle: these different worlds are mixed states of an underlying reality that can be described by a pure state.

Hardy is reluctant to embrace these implications, though. "I'd regard myself as an anti-advocate of the many worlds interpretation," he says. Even D'Ariano is wary of many worlds, although he agrees their work does seem to support it. It's still just a piece of circumstantial evidence for, rather than a proof of, many worlds, he says.

In general, caution is still necessary. "I don't think that any of the sets of axioms that anyone has, including my own, are the final word," says Hardy. D'Ariano, Chiribella and Perinotti are trying to move forward by developing a way to track the evolution of a quantum system. For that they need to work out where specific properties such as a particle's mass fit into their framework. If they can get that right, it might provide more than just a justification for quantum theory: it might be another route to combining general relativity with quantum mechanics. That could lead us to a description of quantum gravity, a "theory of everything" researchers have long been keen to create. Whatever the eventual outcome, at least we now have proof that, when it comes to quantum theory, there is no such thing as a stupid question. ■

Anil Ananthaswamy is a consultant for *New Scientist*

OCEAN commotion

The sea has never been quiet. But are humans drowning out the natural cacophony?
Sandrine Ceurstemont reports

DARLENE KETTEN hoped the morbid express delivery would finally answer some questions. The two beaked whale heads, packed in ice, were flown in from the Bahamas for autopsy in a lab in Boston. The pair had died in an unusual mass stranding of 17 whales on the Abacos Islands. Beached animals tend to be dead when they are discovered, but this time the whales were caught in the act. Local marine biologists returned more than half to the water and preserved the heads of some of those they couldn't save. It was the first time a post-mortem had followed so swiftly after a beaching.

The incident coincided with a US navy sonar exercise nearby. Naval sonar tests have been blamed for driving thousands of whales and dolphins to their deaths. Ketten, who specialises in underwater hearing at Woods Hole Oceanographic Institution in Massachusetts, examined the whales' ears with a CT scanner. She was looking for signs of nerve damage and hair-cell loss, which tend to happen after acute exposure to loud sounds. What she saw was more grisly – and not obviously linked to noise. In both cases, there was blood in the inner ear, but it was draining from a cavity on the surface of the brain. Had sonar really killed the Abacos whales?

The Bahamas case is one of many. Marine mammals have been found stranded on numerous beaches from Hawaii to the

Canary Islands, Greece to Madagascar – all when sonar tests or other noisy industrial activity are taking place nearby. For many, the evidence is cut and dried.

And it's not just mammals that are at risk. Fish and marine invertebrates also seem to be greatly affected by sound. Loud, far-reaching noise – whether from sonar, pile drivers or acoustic guns – seems to cause stress and disrupt animal behaviour. Even the sound of ships could be a problem, especially in busy coastal regions. As ocean development continues, noise pollution is getting worse.

Muddy waters

The question is what to do about it. That's where the waters are muddier. To manage the impact of human noise, we need to understand exactly how it affects marine life. But we are only just beginning to learn which sounds different underwater creatures can actually hear. Or, in some cases, whether they can hear at all. However, the more we tune in to the sounds of the sea, the better equipped we will be to exist in harmony with the animals that live there.

The sea is awash with sound. From whale song and dolphin chatter to the swish of approaching sharks and the gun-crack claws of pistol shrimp, there's a lot for marine animals to listen out for. But there's no question we are adding to this natural



TIM MCCONVACH



cacophony. Industries are continuing to expand into the sea, creating noise pollution from ship traffic, wind farm construction and the seismic air guns used to search for oil and gas. Some noises come in loud bursts, while others are more continuous, drowning out natural ambient levels. In certain areas, measurements suggest underwater background noise has doubled every decade for the last 50 years.

Many human-made sounds are low frequency and in the hearing range of most aquatic animals (see diagram, page 40). What's more, low-pitched sound can travel over huge distances underwater, which is why many animals favour it for communication. But that also means that human noise may have

"Human noise may have a more far-reaching effect underwater than on land"

a more far-reaching effect than it would on land. Sudden sounds, like airguns, can scare animals away from their normal foraging areas, hampering their ability to find food. Drowning out mating calls can stop animals reproducing, and disrupting communication in general can cause animals stress.

After the 9/11 attacks in New York, commercial sea and air traffic halted in most of the world, creating a rare opportunity to look at stress levels in wild whales. Researchers who examined whale faeces in the Bay of Fundy, Canada, at this time found lower levels of stress-related hormones when ships kept away.

So what can marine animals actually hear? Seals are among the first to have their ears tested. They have developed different hearing mechanisms for land and sea and hear well in both environments. For example, seals have erectile tissue in their inner ear, which swells up with blood when they are underwater. "It's like the penis of a man," says Ron Kastelein at the Sea Mammal Research Company in Harderwijk, the Netherlands, who did the hearing tests. The blood in the engorged tissue helps conduct sound waves to the inner ear, allowing seals to hear a slightly greater range of frequencies in water than on land.

Other researchers are studying the effects of noise on fish and marine invertebrates. When scallop larvae were exposed to seismic pulses, for example, many developed significantly more slowly and some ended up with abnormal bodies. Harming these populations can have knock-on effects on the food chain, as well as human food supplies. ➤

And Aran Mooney, a colleague of Ketten's at Woods Hole Oceanographic Institution, has identified the hearing range and sensitivity of cuttlefish for the first time by observing their reaction to sounds played in a tank. Cuttlefish will ink, jet, change colour or twitch to various degrees based on how threatened they feel. But without recognisable ears, some thought they might not hear at all.

His tests suggest that cuttlefish have a hearing range similar to fish. They displayed colourful patterns and moved their fins at all frequencies and levels in this range. But high sound levels also provoked jetting, and loud, low-pitched sounds triggered inking, both escape responses to predators. "The pervasiveness and obviousness of the responses was a surprise," says Mooney. "It was quite clear from the start that we were getting clear responses to sound."

Most invertebrates detect sound by the way it buffets their bodies, rather than by sensing soundwaves directly. A cuttlefish ear, for example, contains a tiny structure that looks like a grain of sand and sits on top of hair cells that sway as the animal moves. The grain lags behind the hair cells as they sway – a motion that is detected and interpreted as sound. "Sound moves them back and forth and they feel the vibration," says Mooney. "It's like being close to a speaker."

Tune in, zone out

One consequence of this is that invertebrates can hear only over short distances, so human noise is less likely to annoy them. Mooney also found that cuttlefish would get used to the repetitive tones he played underwater, dampening down their response over time. But it is hard to work out if that would be an advantage. "You can adapt to a loud rock concert but it might still deafen you," says Mooney. "Behavioural adaptations don't necessarily prevent damage."

Certain whales also seem to be able to live with intrusive noises to some extent. Peter Tyack at the University of St Andrews, UK, and colleagues found that when noise from commercial boat traffic interferes with the sounds right whales use to communicate, they modify the sound levels and frequencies that they emit. But their ability to compensate has its limits as there is a physical threshold to the sounds a whale can make, says Tyack. If human noise continues to increase, adjusting their signals may no longer be enough.

However, responses to noise can differ greatly between close cousins and even



Loud noise can cause whales to panic, sometimes with fatal consequences

between individuals of the same species. Ketten's whales weren't the only ones in the area at the time of the beachings. Other nearby whales, including beaked whales, were unharmed. In fact, instead of fleeing sonar, some whales – like pilot whales – are attracted to it and sperm whales mostly seem to ignore it, though it might reduce their ability to catch prey.

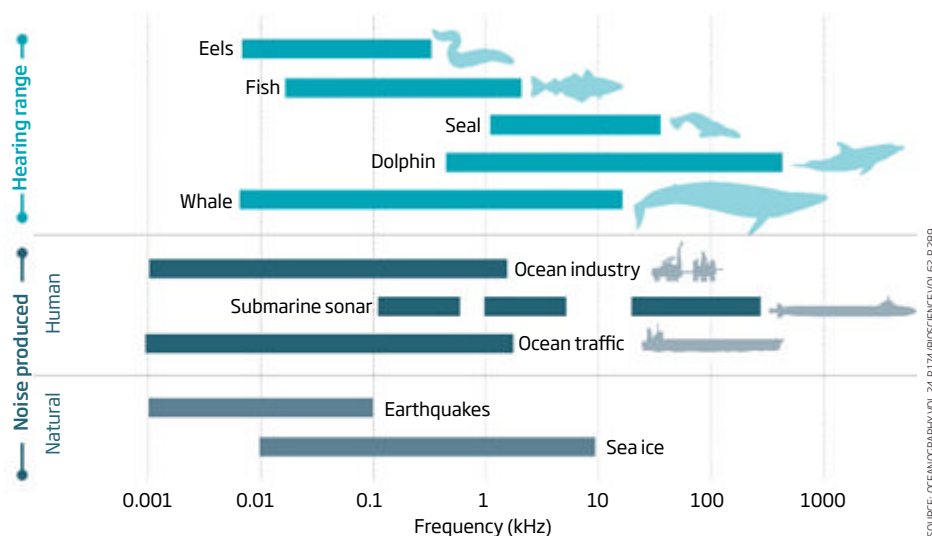
After examining the heads of her whales, Ketten ruled out sonar as the direct cause of death. The blood-filled ears were not the result of injury inflicted by sound. Nor was

there evidence that their hearing had been dramatically affected. Instead, Ketten concluded that the haemorrhage was probably caused by a dive gone wrong – the whales failed to adjust properly to changes in pressure by ascending too quickly or remaining deep down for too long.

Even if sonar didn't deliver the final blow, however, Ketten thinks it could have provoked unusual behaviour in the whales that ultimately led to their deaths. "My best guess is that the beaked whales were disturbed by the sound of the sonar and panicked," she

Sounds of the sea

Many human-made sounds are in the hearing range of marine mammals



SOURCE: OCEANOGRAPHY VOL. 24, P.174; BIOSCIENCE VOL. 62, P.259

HEAR TODAY, HEAR TOMORROW

Sea anemones listen out for prey with adjustable ears. Sugars given off by passing tiny organisms like shrimp plankton bind to bundles of hair cells on the anemone's tentacles, making the hair cells grow. The longer hairs are better at detecting the low frequencies produced by swimming prey.

"It's a lot like a slide guitar," says Glen Watson at the University of Louisiana at Lafayette. "When the string is long it's a low frequency,"

That's not the anemone's only trick. The vigorous movement of approaching prey often damages the bundles of hairs. But anemones have the tools to fix them: they quickly secrete a mixture of proteins that repair the bundles in about 4 hours.

The anemone's repair mechanism is an example of how indestructible animals can be, says Watson. It was the ability of some anemones to reproduce by ripping themselves in half that prompted him to investigate. He doubts anemones are affected by human noise (see main story). "They are incredibly resilient animals," he says.



Indeed, Watson thinks humans could benefit from the sea anemone's toolkit. By isolating the repair proteins, Watson found that he could regrow hair bundles in fish and he has new evidence that these proteins can repair hair cells in mammal ears, too.

Unlike fish, mammals don't have the ability to repair their sensory cells, so exposure to extreme noise can lead to permanent damage. Since the proteins need to be injected before hair cells die, Watson thinks they could be given to us before we are exposed to loud noise as a form of protection against hearing loss.

says. "I've seen the same type of bleed in humans: it can happen to haemophiliacs when they are upset." While trying to escape the sound, the whales may have aborted a dive too quickly and ended up on land.

So how can we protect sea creatures from our noise pollution? Kastelein and colleagues have developed a way to keep animals a few kilometres away from noisy areas.

They built three devices, each tailored for seals, porpoises or fish, that emit a randomly generated playlist of sounds through underwater speakers to make the animals swim away. The sounds are played at irregular intervals to avoid habituation and the volume is increased gradually to minimise any stress caused by the device itself. Ascending tones mimic the rise in frequency that would happen as something approaches. "Upsweeps sound awful to all mammals," says Kastelein. "Alarms and cellphone ringtones use them to make you pay attention."

So far, the fish deterrent is working. A Swedish dredging company that was exploding dynamite underwater to enlarge a harbour found no fish among the rubble. Similar endeavours have killed thousands. The porpoise deterrent has been used in the Netherlands during wind farm construction, where laws forbid the killing of porpoises, and the system has also been rented for seismic surveys.

Christ de Jong at the Netherlands Organisation for Applied Scientific Research is looking at noise created by ships. As part of the European Sonic project, he is targeting propellers, the biggest source of underwater noise from most ships. In fast-moving vessels, propellers can produce cavitation bubbles – pockets of low pressure in a liquid that generate a shock wave when they implode. This effect is behind the gun-crack of a pistol shrimp's claws, which can stun and even kill small prey. By redesigning ship propellers and hulls we can reduce the noise they make, says

de Jong. "Designers need to label propellers in terms of noise levels so that shipyards have a choice of quieter alternatives."

The Sonic project is also drawing up sound maps of the North Sea that track the location of ships, showing a vessel's size, for example, and modelling the sound it radiates. "We use the maps to investigate how the total noise in the sea would be affected if shipping noise requirements were set to a certain level," says de Jong. The maps will also incorporate information from biologists about where different species live, and at what depth, so that ships can exercise more caution in areas with sensitive species.

Kastelein also thinks we could tweak industrial noise to make it less disruptive. Airguns, for example, are already using narrower beams in seismic surveys to reduce the area of the seabed hit by the sound.

"Even if sonar did not deliver the final blow, it may have led to a fatally aborted dive"

In future, sonar on ships could also use descending tones rather than ascending ones, as animals find these less threatening.

At present, there are rules governing noise for certain activities that require permits, such as wind farm construction and seismic oil exploration. But there are no general international regulations and no rules about shipping. Ketten and de Jong are calling for better protection for marine life based on our growing understanding of the relationship between human noise and animal behaviour. This is at an early stage, though, says Ketten. For now, awareness is helping. In the US, for example, the military now watches out for beaked whales when using sonar at their bases. When an animal is spotted, they quickly reduce sound levels.

The sounds of the sea are less mysterious than they were a few years ago. But Ketten feels she has a responsibility to identify what she calls the perfect storm of terrible conditions that can lead to disaster – such as multiple ships using loud sonar in an enclosed area where whales are trapped. Post-mortems are not likely to provide all the answers. "We have no relatives coming forward to tell us about an animal's history," she says. "We have to piece everything together as best we can." ■

Sandrine Ceurstemont is video editor at *New Scientist*

Going, going...

Alun Anderson on an insider account of the Arctic's unravelling

Future Arctic: Field notes from a world on the edge by Edward Struzik, Island Press, \$27



FOR much of the past 35 years, Edward Struzik has been travelling around the Canadian Arctic by canoe, kayak, dog sled, sailboat,

bush plane, helicopter and ice breaker as well as on foot and ski.

For many Canadians, his writings from the far north will be immediately familiar. But *Future Arctic* should be the book that introduces him to the rest of the world because his unique voice needs to be heard.

In places so remote that few of us can locate them on a map let alone expect to visit, Struzik paints troubling pictures of an unseen Arctic that is on the brink of unravelling under human pressures both near and far.

He endures all the discomforts of the Arctic during his travels: vast storms, freezing cold, long journeys in heaving sailboats and clouds of biting insects so dense that you leave a wake behind you as you walk through them.

In one place where Struzik seeks shelter his host shocks him awake in the night by firing a rifle through the front door at a marauding bear. There are places that are sublime and others, like Ellef Ringnes Island, which are “closer to Hell than to Earth”. As he writes: “Nowhere is there a speck of colour or a hint of life, just nature in despair.”

The unique advantage of Struzik's travels is that his “field notes” allow him to relate an intimate knowledge of place



PAUL NICKLEN/NATIONAL GEOGRAPHIC CREATIVE

No safety in numbers: vast herds of Arctic caribou are in decline

back to widening circles of global influence.

Visits to the Peace-Athabasca delta prove the value of his method. The Peace river, flowing east from the Rockies, and the Athabasca river, flowing north through Alberta, meet in the middle of nowhere to create the world's largest freshwater delta, a maze of lakes and winding channels.

Many indigenous people used to make a good living in the delta from its fish and wild fowl. Struzik meets Cowboy Joe Wandering Spirit, the last person to still live there all year round, alone in a one-room cabin with his 10 sled dogs. The middle of nowhere is not far enough away to escape

human influence, it turns out.

In 1967, a huge reservoir was completed far away on headwaters of the Peace river in British Columbia. Since then the delta has been drying out, with lakes and channels vanishing, despite efforts to release enough water to keep it healthy. “The Canadian government knew then that the dam would have an enormous effect on the delta downstream, but no one bothered to tell anyone who lived there,” he explains.

Then came the oil sands industry, a couple of hundred miles up the Athabasca. In 1986, a massive spill polluted the delta

leaving locals in fear of another.

And as the oil sands industry grows, it sucks ever more water from the river: 2 per cent of its flow now, rising to perhaps 30 per cent in 2030, Struzik tells us.

In the far-off mountains where the rivers begin, global warming continues to melt the snows and glaciers that give the rivers life. The circles of human interference close in on the delta, with the one ray of hope that a wetter phase of a climate cycle may be on its way. But to be sure of that we need better long-term data. And, this, Struzik explains, is increasingly difficult when “the Conservative government of Prime Minister Stephen Harper has been hostile to climate change debates, toward scientists, and toward most environmental initiatives”.

The fate of the caribou is

“Much can be done... and Struzik's book demands action, not resignation”

another of Struzik's many stories with the same structure. Caribou live in vast migratory herds across the Arctic but most are in decline. In 1986, there were 450,000 in Nunavut's Bathurst herd; by 2009, only 32,000 were left.

Over-hunting is one factor that can be quickly reversed. The wider circles are beyond local control. Warmer climates bring more insects and diseases. More rain and less snow create layers of hard ice that prevent caribou reaching the lichens they feed on. More development in the Arctic carves up the old forests, allowing deer to move in along with wolves that feed on them but then take caribou, too. Once again, all these impacts are superimposed on natural cycles that we don't understand.

Despite Struzik's often worrying accounts drawn from across the Arctic, on land and in the ocean, he is neither an ideologue nor a pessimist. A penultimate chapter looks at arguments for an international treaty to protect the Arctic. But this is largely superfluous for, like everyone else, he sees no practical route to its realisation.

He scores much better on solutions to individual problems: there are ways to protect calving caribou, and a water management scheme used in Texas may be just what is needed to help the Peace-Athabasca delta, for example. There is much that can be done to ameliorate each individual problem and Struzik's book demands action, not resignation or anger.

But lurking in the background is the seemingly unstoppable force of changing climate, bringing a flood of unfamiliar creatures to the north, which Struzik records, and creating a new Arctic that we cannot yet imagine. ■

Alun Anderson is a consultant for *New Scientist* and author of *After the Ice: Life, death and, geopolitics in the new Arctic*

Once upon a time

Stories woke young Victorians to science, finds **Jonathon Keats**

Science in Wonderland: The scientific fairy tales of Victorian Britain

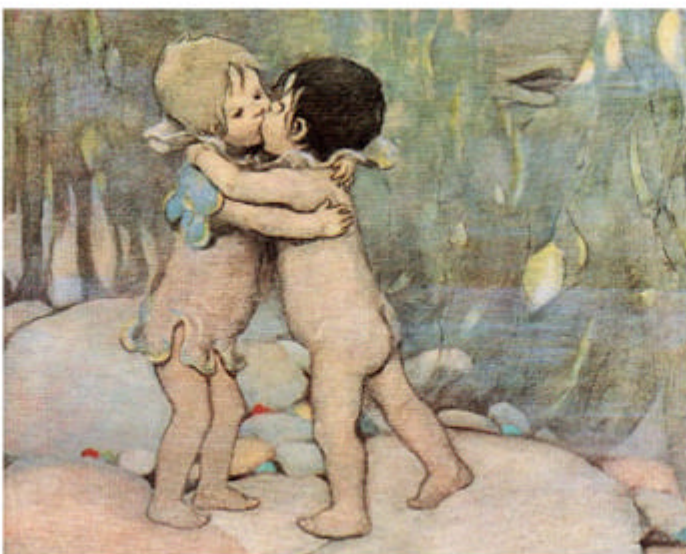
by Melanie Keene, Oxford University Press, £16.99



"DRAGONS and fairies, giants and witches, have vanished from our nurseries before the wand of reason," wrote the poet Lucy

Aikin in 1801, lamenting the triumph of facts over fancy in education. Her eulogy was premature. Although driven by science and technology, the Victorian era that followed was no enemy to fable. On the contrary, as Melanie Keene argues in *Science in Wonderland*, the 19th century was a golden age for fairy tales, and these tales also made scientific advances engaging for young audiences.

Chemical bonding: fairy tales had a scientific value for the Victorians



JESSIE WILCOX SMITH (1863-1935)/PRIVATE COLLECTION/BRIDGEMAN IMAGES

Of course, some adjustments were required. *Jack and the Beanstalk*, for example, was a poor primer for botany, and even worse for structural engineering. A historian at the University of Cambridge, Keene has meticulously documented the transformation of fable from the magical to the rational, and shows why it happened.

Probably the most obvious realm for revisiting myths was palaeontology, because newly discovered fossils evoked the bones of story-book monsters. In *The Fairy Tales of Science* (1859), John Cargill Brough sought to reclothe "hard and dry" technicalities "in the more attractive garb of fairy tales", and his chapter on dinosaurs was true to his word, depicting a dual between a *Hylaeosaurus* and a *Megalosaurus* as an epic battle between "dragons".

Fairies even featured in the teaching of new science. In Brough's tales, electricity was an

Amber Spirit put to work as a courier running up and down the transatlantic telegraph cable. Other authors associated fairies with insects, especially butterflies. And Albert and George Gresswell's *The Wonderland of Evolution* (1884) depicted chance as an airy magic sprite.

Yet the strangest employment of fairies, at least to modern eyes, was in Lucy Rider Meyer's 1887 *Fairy Land of Chemistry*.

"Although driven by science and technology, the Victorian era was no enemy to fable."

The book's premise, Keene writes, "was that atoms should be thought of as fairies, whose behaviour, dress and even limbs reflected their chemical properties". For instance, Meyer asserted that chlorine fairies are "never a moment alone" (due to the element's reactivity), and she depicted water as two hydrogen fairies holding hands with an oxygen fairy. Meyer was both a chemist and a Methodist, and her fairy land was both scientific and spiritual.

There is an abyss between Brough's demystification of palaeontology and Meyer's spiritualisation of chemistry, and Keene sees this as characteristic of the anxieties of the era. To engage the wonders of science requires a suspension of disbelief. These authors hoped that children who grew up on scientific fables would be better able, as adults, to wield the wand of reason. ■

Jonathon Keats is an experimental philosopher and artist

On loving lemurs

A primatologist's diary sheds unusual light on Madagascar's conservation, finds **Adrian Barnett**

Thank You, Madagascar: The conservation diaries of Alison Jolly, Zed Books, £18.99/\$27.95

IN THE early 1960s, Alison Jolly was one of a small coterie of women who took on the male-dominated world of primatology with its focus on aggression and hierarchies. Jane Goodall, Biruté Galdikas and Dian Fossey studied apes; Jolly chose lemurs.

She died last year, aged 76, and *Thank You, Madagascar* is the last of her journals detailing a long and productive career. One of her first discoveries is highlighted because it still raises eyebrows: the world of lemurs is generally female-dominated. Many species form long-term pairs, but females run the show, deciding where to go, when to forage and getting first dibs on delicious morsels.

Male ring-tails may have spurs on their wrists, but they use them to gouge plants, not opponents. When territories need defending, it is the females who charge, while the males look on, meaningfully perfuming their tails from scent glands. As Jolly writes, if a female wants the tamarind pod a male is holding, he has no choice: he must paw it over, with high-pitched "I am so sorry" squeaks.

There is lemur biology aplenty in the book, but, like a fine soup, it's one ingredient in a rich mix. Jolly's time in Madagascar began shortly after the country's independence from France in 1960. Using diary entries, letters and emails, *Thank You, Madagascar* records the country's tricky history, its biology and anthropology, the sociology of researchers, politicians and aid workers and how they all came together in conservation. This

lens provides a unique insider's account of major environmental efforts in one of the world's biodiversity hotspots.

Biologically, Madagascar is one of the planet's richest counties; in human terms, it is one of the poorest. About 72 per cent of its people survive on less than \$1 a day, 50 per cent of adults are uneducated, over 70 per cent of the population are under 15 and almost everyone is underweight.

Its ecology suffers as well. Soil erosion costs the country between \$250 and \$300 million annually – 10 per cent of its GDP – and less than 15 per cent of its forests survive. But burning the land is culturally ingrained. School and university alumnae are called "well-burned land", implying fertile hope for the future. Madagascans, Jolly says, "feel a profound, indeed sacred, link to their land... They do not see

themselves as forest destroyers, but as enrichers."

Village records reflect these roots, dividing locals between the king's kith and kin, vahiny – visitors, only there for a few generations – and vazaha (foreigners), which includes tourists as well as water and forest department officials.

With this as background, Jolly documents the hopes, visions, cultural misinterpretations,

"Biologically, Madagascar is one of the planet's richest countries; in human terms, it is one of the poorest"

group-founding, group-feuding and individual involvements: all these are defined, bedevilled or empowered by conservation on an island the size of California. She begins with colonial decrees prohibiting hunting, continues through global conferences and World Bank structural adjustment programmes on to village

meetings and the history of three different local protected areas.

All of this is recorded with the empathy, humour and insight of one who loves wildlife and knows it takes committed people at all levels to give effective protection.

Whether Jolly recounts World Bank president Barber Conable listening to indri lemurs at dawn, or recalls an astute minister manoeuvring colleagues into pro-conservation action, she links an acute eye for detail and lyrical moments with a puckish appreciation of the bizarre – a good survival trait in Madagascar.

But there is a wistfulness, and you feel however many reserves are established or Madagascan scientists are trained, Jolly would like to have done even more, for, as she reminds us, "I care so much about this funny country, which isn't even my own." ■

Adrian Barnett is a rainforest ecologist at Brazil's National Institute of Amazonian Research in Manaus



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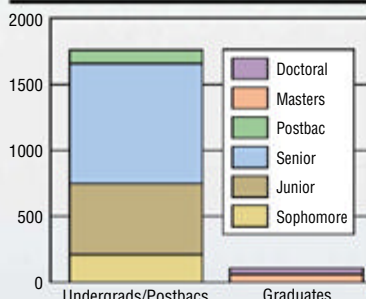
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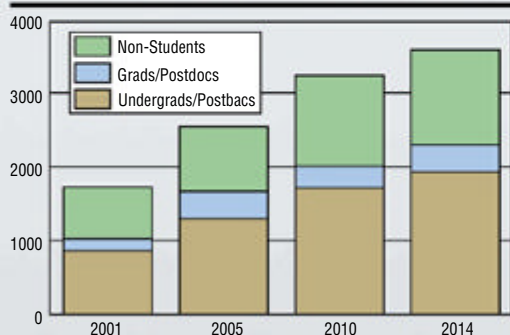
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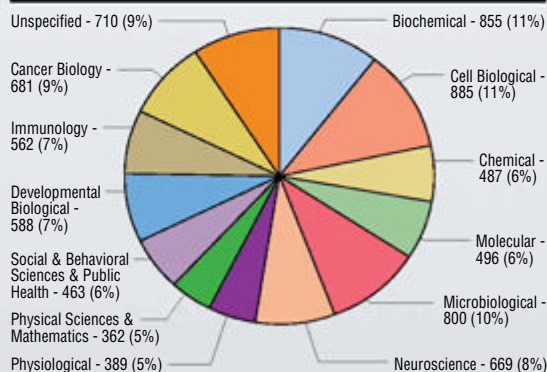
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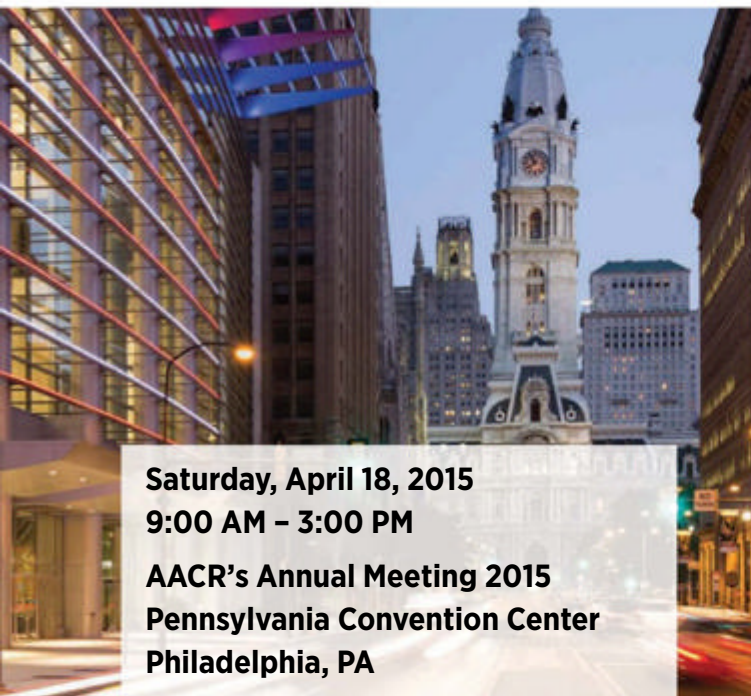
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For questions, please contact Dr. Nanine Van Draanen at nvandrraa@calpoly.edu.

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Please email academicservices@bates.edu for further consideration, and don't forget to mention you saw us in New Scientist Magazine.

EDITOR'S PICK



Antibiotic crisis long in the making

From John Hastings

Why has it taken so long for the “antibiotic apocalypse” (21 March, p 22) to get a hearing in policy-making circles? I started my training as a nurse in 1968. Though we did not have to learn about the biochemistry and pharmacology of antibiotics and of course did not prescribe any medications, we certainly learned about the practicalities of antibiotic treatment.

We were taught that, in any case of infection, it was good practice to identify not only the bacterium responsible but also its sensitivity or otherwise to a range of antibiotics; and that we should do this rather than prescribe a “broad-spectrum” antibiotic.

We learned that it was preferable to prescribe a course of antibiotics over a set number of days rather than (as many doctors did) “prescribe and forget” so that patients could be receiving the same antibiotic for two or three weeks, whether they needed it or not.

We also knew that combining two antibiotics made it more difficult for bacteria to become resistant to either. And we were taught that bacteria could develop resistance to antiseptics as well as antibiotics.

The medical profession has known about antibiotic resistance for the best part of half a century. What have they done about it? Not very much.

Whittlesey, Cambridgeshire, UK

Laying ground rules for free will

From Carl Zetie

Randomness is not by itself sufficient to “admit free will” in an otherwise mechanical universe (14 March, p 28). At a minimum, free will requires that the outputs of my brain are not completely determined by the inputs plus the initial state. This is unlike any other known physical system or law. Introducing randomness merely allows for a range of outcomes distributed probabilistically, but still with no element of intentionality or purpose – the other essential ingredient in free will.

One intriguing possibility is that whatever free will might be, randomness provides a means for it to influence the brain without apparently violating known physical laws over the long term. Such a brain would be like a rigged roulette wheel that comes up red or black at the casino’s choosing, but must still ensure that the two come up equally over the long term if it is not to be caught breaking the rules.

Some experimental results are consistent with this model. For example, behaviours that we usually consider as exercising free will, such as paying attention or resisting temptation, can be exhausted. This is despite the fact that they don’t seem to be associated with anything as obvious as depletion of neurotransmitters. This is what we expect if free will can only influence a limited number of outcomes while staying hidden within known physical laws.

Whatever free will turns out to be – assuming it exists at all – understanding it will take at least as great a conceptual leap as that from classical mechanics to quantum theory. And perhaps it is only chance that binds these three views of reality into a consistent, scientifically explicable universe. Waterford, Virginia, US

From Peter Abrahams

I suggest another definition of free will: that people have free will because they can make conscious decisions that can neither be predicted, with absolute certainty, by any other person nor be dictated, with absolute certainty, by another person.

It is irrelevant that these decisions are made by our brains, which are part of the physical world and controlled by the laws of nature and therefore predictable, in principle. For a computer to make such a prediction, it would have to be as large and as old as the universe.

A clear definition removes the conflict between determinism and free will and may let us get on with more relevant and interesting discussions. London, UK

Green spirits soar on coal bust

From Gerald Sutliff

Fred Pearce describes how a “coal bust” may be behind the stall in carbon emissions (21 March, p 16). Thank you for publishing an item that keeps hope alive and gives we Greens cause to celebrate. Bakersfield, California, US

Infinite planet and our false economy

From Liegh White

I am interested that Andy Haldane of the Bank of England now looks to several scientific “ologies” for guidance (28 March, p 28). But your interview does not mention any questioning of the base assumption of the present economic system: namely that we inhabit a world of infinite resource in which pollution has no consequences. Perhaps he also needs to consult a class of 5-year-olds for advice! Keyworth, Nottinghamshire, UK

Food fit for a Red Queen

From Justine Butler

Isotopes in dental enamel from the Red Lady of El Mirón revealed that 80 per cent of her diet was meat from hooved animals, the rest being fish, some starchy material, seeds and mushrooms (21 March, p 8). You describe this as “the Paleo diet, for real”. The Red Lady was, however, no ordinary woman.

The circumstances of her burial were exceptional; she was painted in red iron oxide pigment. She was probably a queen or a leader.

Last year, isotope analysis of bone and tooth material from King Richard III revealed that he ate swan, crane, heron and egret and drank plenty of wine. That would hardly have been the typical diet in medieval England. Bristol, UK

Perceptions of probability on trial

From Allan Reese

Regina Nuzzo gives a fair account of the conflicts between frequentist and Bayesian statistics (14 March, p 38), and I agree with the conclusion that applied statisticians generally combine both approaches. The starting point of frequentist statistics – the “null hypothesis” with which results are compared – is generally a straw man. The anticipation of finding a relationship when we choose what data to collect echoes the Bayesian “prior probability”. A bigger issue is the untestable assumption that the data form a representative sample of a wider population or distribution.

It would be interesting to know, as a case of everyday Bayesianism, the prior beliefs that people bring to courtrooms. What do jurors think before the case has started? The presumption of innocence cannot correspond to zero

f “Nothing is certain – not even the uncertainty principle”

Waseem Lone posts last month in response to “celestial signals that defy Einstein” (4 January 2014, p 30)

probability of guilt. Prosecutors decide to bring cases based on an estimated “reasonable probability” of conviction.

I hope that each juror starts with a personal estimate of the probability of guilt before hearing evidence – informed, for example, by the proportion of prosecutions that lead to guilty verdicts. They can then evaluate the evidence to compare the likelihoods under hypotheses of guilt or innocence, arrive at a probability of guilt, and compare that with their personal standard of what is “beyond reasonable doubt”.

The law in the UK does not allow observation of the jury process to test that explanation. My personal prior belief is that it is hopelessly optimistic. *Forston, Dorset, UK*

When charity goes wrong

From Bryn Glover

It is always depressing to read about humanity's apparent complete inability to learn from

its own mistakes, and Simron Jit Singh's account of inappropriate disaster relief is a prime example. (21 March, p 34).

It reminds me of when the so-called EMI scanner was marketed in the early 1970s. Groups sprang up in the UK to raise funds to buy one of these new wonder machines for their local hospital.

The machine was an axial tomographic unit using X-rays. It was only large enough to take a patient's head. Nonetheless it was universally hailed as the answer to diagnosing all brain disorders. Many scanner appeals were organised without consulting hospitals, which were then presented with machines with very little prior warning.

I know of one scanner that was duly delivered, but then stayed in its packing crate for at least two years in a major hospital's basement store. When it disappeared, rumour had it that managers had sold it to another hospital that actually wanted it. The first hospital had nowhere to install the scanner and no staff to run it, or available for training. They also couldn't afford to pay

the running costs or for its eventual replacement.

Such stupidity never occurs these days, because philanthropic organisations have learned to work with local equipment purchase prioritising schemes, and only buy what the professionals have agreed they want and need.

How very sad to read that, presumably, highly organised professional relief organisations have yet to learn that simple lesson from the UK health service of 40 years ago. *Glasshouses, West Yorkshire, UK*

Enceladus's mystery heater

From Chris Goldfrap

Saturn's moon Enceladus is getting attention as a possible venue for life. Last year you reported that “as Enceladus orbits Saturn, changes in the planet's gravitational pull flex the moon, but... a stiff rocky core would not flex enough to generate the heat necessary to melt the ice”. But when researchers modelled a core

“more like a snow cone than a stone, it flexed and created enough heat to fuel its famous water jets” (1 November 2014, p 17).

Now Hsiang-Wen Hsu of the University of Colorado thinks that “tidal heating, generated by the squeeze of Saturn's gravity, wouldn't provide enough energy” for chemical reactions producing sand grains ejected into Saturn's rings (14 March, p 11).

Does this imply an as-yet-unknown alternative source of heat? I would be fascinated to read more about the convergences and differences between the findings of these two projects. *Wallingford, Oxfordshire, UK*

The editor replies:

■ So would we, and we also look forward to finding out whether both reports are true, and how.

Lights! Camera! Metamirror!

From Ernest Ager

Metamirrors that reflect face-on light at 45 degrees (14 March, p 16) are not quite new. Whenever an actor shaves or does their hair in a mirror, how do you think the camera (at an angle) manages to capture them face-on when they are shown apparently looking at themselves?

Exmouth, Devon, UK

For the record

■ Flaring off 10 million cubic metres of methane gas will produce about 18,000 tonnes of carbon dioxide (28 March, p 20).

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TOM GAULD





WHAT should we call the phenomenon exemplified by Feedback's perception that "anyone who suspects the probability of a set of independent failures occurring together to be vanishingly small should urgently make plans to cope with them all happening at once" (7 March)? So far, 21 readers have been keen to help.

Six of you suggested Murphy's law, also known as Sod's law: "Anything that can go wrong, will go wrong." Bill Sloman noted the "necessary corollary that whichever name you use for it won't be the one used by the person you are talking to". Bob Malcolm was reminded of a journalist asking a UK Met Office spokesperson, in the aftermath of some weather phenomenon, "Why can't you predict these freak events?"

Bob also likes the "Law of the Inevitability of Freak Events", or LIFE. This has the advantage of being, like the original question, a bit more specific than Murphy's law, which seems to us to be primarily about

maddening individual failures. So, too, does Pat Phillips' suggestion of "Black Swan" after Nassim Taleb's book of that name about unpredictable events. Tony Rimmer may have got to the heart of the difference with his suggestion of "polymorphism".

THE above question also led to inventive portmanteau words: in the context of untoward nuclear events that we mentioned, Ian Beaver's "complacident"; Alex MacDonald's "improbaballs"; and Russ Carlson's "coincidentalency". The last should, he proposes, be pronounced, improbably, "koh-inky-dink-al-itee".

THE late Terry Pratchett also inspired a number of suggestions for naming the phenomenon of the inevitability of improbable combinations of events. Following some unfortunateness with a laser printer - whose tendency for multiple errors our own editor was grumbling about just the other day -

and recalling Pratchett's reaction to his Alzheimer's diagnosis, Ian Lang puts forward "The Ratio of Omnibuggerance".

Sandy Dalkin posits "Rincewind's Rule", named after the hapless wizard of Pratchett's *Discworld* novels, in whose experience things with a one in a million chance of happening "crop up nine times out of 10". He also proposes "Pratchett's Postulate".

THERE is, of course, a serious side to the analysis of polyfailure, and in the world of aviation it has a name. Pete Culman writes: "The overall risk of an incident occurring is considered as the cumulative risk of a number of 'layers', each having 'holes'. The layers move with time: an incident will occur only if enough holes line up simultaneously for long enough." The prevention of this is, by visual analogy, the study of "Swiss cheese".

David Harris credits this to the psychologist James Reason. David adds, in defence of aviation in general: "Observation shows around two human errors per flight, but these proceed to an accident in fewer than one flight in a million, about one in two million hours. The biblical 'three score years and ten' is 613,607 hours. If you spent your entire life in an airliner, you'd be unlikely to die in a crash."

NOMINATIVE determinism - the notion that names influence occupations - has been celebrated by our colleague Richard Webb at the Ig Nobel roadshow - itself a celebration of "research that makes people laugh, and then think".

"What I'd really like," Richard says, "is an assessment of the probability that, in the very week I am taking nominative determinism to the country, I should, at a schmoozing event at the Science Museum on my off night, be randomly approached by a stranger who turns out to be Roger Kneebone, professor of surgical education at Imperial College London, and subject of one of my slides, who subsequently ends up appearing in

the show that just happens to be at Imperial College two nights later."

This all happened in a week when the subject of *New Scientist's* cover special was chance - in which David Hand, also (no doubt coincidentally) of Imperial College, informs us that "what appear to be extremely improbable events occur quite often".

These would appear to be relatively benign examples of polymorphism, defined above. It leads Richard to fear that he is, in fact, living in the Matrix.

ALATRISM is defined, largely by Feedback, as "not bothering to worship any deities, regardless of how many there may be" (21 March). Carl Zetie suggests it "appears to be somewhat related to apatheism, defined as 'really not caring whether or not there is a god or gods.'" Perhaps one might say that apatheism is to alatrism as atheism is to agnosticism?

The best part about being an apatheist, Carl says, "is that it annoys militant atheists and religious fundamentalists in equal measure".



FINALLY, and still considering untoward events, Nigel Perry has a plea. "Almost every day we read that certain vile instruments have been used for drug dealing, child abuse, fraud and countless other felonies. Please support my campaign for a ban on industrial scales."

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Brian Russell spots an exciting development in chemistry: "Seer Rockdust... is 420 million year old volcanic rock, finely crushed to release... minerals and trace elements - 100% organic!"

Gimme the plane truth

I have often been told that plane trees in London can cope with the high levels of pollution in the city because they draw it into their bark, which they then shed. Is there any truth in this?

■ Plane trees are particularly numerous in London because they are able to remain healthy despite high levels of pollution. It was for this reason that large numbers of them were planted during the industrial revolution, when pollution in the city was particularly high. Many survive to this day.

All trees absorb gases through their trunks. Their bark is full of tiny pores called lenticels. These allow air to reach the wood inside,

process that gives the trunks of plane trees their mottled appearance.

*Lewis O'Shaughnessy
Salisbury, Wiltshire, UK*

Heart to heart

Why do animals have organs? Surely it would be more efficient and robust for us to have a thousand tiny hearts distributed round our bodies rather than one big one in the middle?

■ Insects and other small creatures have no hearts; instead, they have a dorsal vessel that contracts in several segments to circulate haemolymph around the body.

This fluid does not carry oxygen, however, because the gas exchange required for respiration can be accomplished by simple diffusion from the surrounding air. Bigger creatures such as ourselves need a more densely packed surface for gas exchange (such as gills found in fish or lungs in other animals), a network of blood vessels to transport the gas and a pump to push the blood around.

The heart is evolution's best attempt at a high-pressure pump and, in terms of power-to-weight ratio, it is likely to outperform a distributed system. However, this arrangement does introduce friction between the blood and the vessel walls. Therefore, the blood pressure needed to operate a closed circulatory system increases with body mass.

Taller animals must also force blood higher against the force of gravity.

The idea of having redundant hearts is nice but, for this to work, each little pump would need to have its valves open if it fails, so that blood could still be pushed through it. To maximise efficiency, each heart would have to beat when the pressure at its inlet was at a maximum, a far more complex task to manage than a single heartbeat.

*Mike Follows
Sutton Coldfield, West Midlands, UK*

Gloomy side up

Whenever I make scrambled eggs, they turn out grey. What causes this?

■ If you remember your chemistry teacher heating a mixture of iron filings and powdered sulphur to form iron sulphide, with a whiff of egg hydrogen sulphide in the air, you've experienced the chemistry behind the grey eggs.

Iron from the yolk combines with sulphur from the egg white to form grey iron sulphide, especially so when overcooked. If you cut a hard-boiled egg in half, you will see a band of greenish-grey iron sulphide at the interface of the yolk and egg white. The colour is caused by the mixing of the grey sulphide and yellow yolk.

To avoid grey eggs, cook them less or, if you insist on having well-cooked eggs, add a drop of

yellow food colouring to brighten up breakfast.

*David Muir
Edinburgh, UK*

This week's question



CAFFEINE SHAKES

I am a regular traveller between the Scottish island where I live and the mainland. The vibration on the ferry sets up an interesting interference pattern on the surface of a cup of coffee. It forms quickly after the cup is put down then remains fixed. Presumably, waves are reflected from the sides of the cup and subsequent waves reinforce the earlier ones. The pattern remains as the coffee level gets lower. In the interests of research, perhaps next time I should investigate whether the effect occurs in a glass of beer! An explanation would be appreciated.

*Jack Harrison
Tobermory, Isle of Mull, UK*

"The trees can quickly shed their outer layer of bark, which is laden with pollution"

where gases such as oxygen are vital for processes like respiration.

In cities, these pores often become blocked with pollutants from factories and vehicles, and these become visible as black dots on the bark. What sets plane trees (and some other species like birch) apart is the rapid rate at which fresh bark grows beneath the outer layer.

This means that trees can quickly shed their outer layer of bark, which is laden with pollutants. It is this shedding

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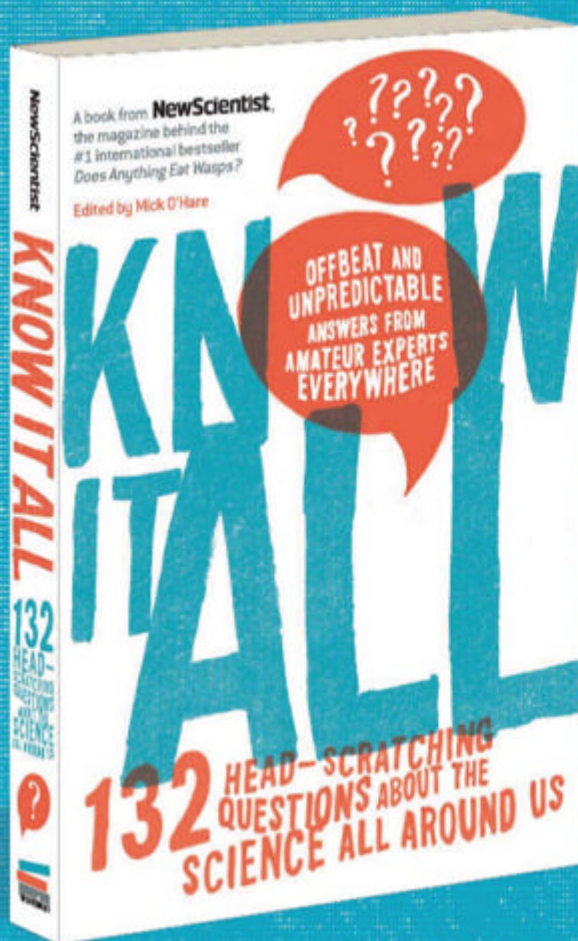
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